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What is a Cultural Physics Course?[1]

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IF there were relatively as many high-school and college students studying physics today as were studying it thirty years ago, we should have about three times as many physics teachers as we now have. The relative number of students studying some science has increased slightly, but the increase has been in the fields of chemistry and biology, while physics has suffered a large relative decrease.

The plain fact is that while some students study physics in preparation for the vocations of engineering, medicine and scientific research, fewer and fewer of those for whom the study of science has no specific vocational value are studying physics. We are losing the students for whom the study of physics is said to have "cultural" value. Many of us believe thoroughly that the study of physics does have cultural value. We believe that physical science should play an important part in the general education of every man, no matter what his calling is. But we face the fact that the science we teach is attracting fewer students.

Why has physics lost popularity? The answer is not simple. There are physics teachers who believe that physics courses have lost popularity because of a weakening of the intellectual fiber of college students during the past few decades, since college halls have been thronged with boys and girls who possess very little interest in and aptitude for the affairs of the mind. These teachers believe that physics must be a difficult study if it is to be worth anything to a student, and they say that students have neglected physics merely because it is so difficult. This view of the matter has some validity, for, compared with the student of today, the college student of the previous generation was a selected individual who lived in an atmosphere of belief that there was value in doing a thing that was difficult, whether it had meaning for him or not.

But we must not allow the limited truth of this view to blind us to the fact that our physics courses lack cultural value. Our elementary physics courses, with few exceptions, do not meet the need of the student who wants to get from his study of science a contribution to his general education. There is no doubt that our loss of students is partly due to our failure to give them what they need.

Everyone knows that recently a number of attempts have been made to meet this need. There have been courses developed in the special field of physics which are designed to contribute to the general education of a college student. These courses have been called, as a rule, "cultural courses." Also there have been established "survey courses" or "integrated courses," in the general field of physical science. Many of the courses of both types are very good, I believe, but I doubt that we shall find an extension of them as the immediate solution of our difficulty.

[1] Presented at the Atlantic City meeting of the American Association of Physics Teachers, December 29, 1932.

I believe that we cannot look for any greater expansion of such courses in the near future, for reasons connected with finances and administrative policies in our colleges. A large fraction of our colleges offer but one elementary course in physics, with so few students that they can be taken care of in one section. These colleges cannot pay for a new cultural or survey course in addition to the present course in general physics. Such a course would mean added expense in caring for the same students now cared for by the existing battery of science courses, A college administrator will hesitate long before setting up a new course which will cost money and disturb the equilibrium of interests which always exists in a college faculty. Only in the large colleges can new experimental courses be added without too great expense and without arousing jealousies. While words do not easily fit the foregoing argument, I believe that it will be appreciated by anyone who is familiar with the delicate balance of interests in a college faculty at a time like the present, when the period of growing enrollment seems to be over and retrenchment is the order of the day.

I would not argue against the establishment of special cultural courses where they can be established. Wherever general reorganizations are being made we may hope and work for changes in the science curriculum which will result in new courses designed to form a part of the general education of the student. But the great majority of colleges do not seem to be changing rapidly, and it is in such colleges that we need to find a way of giving the elementary physics course greater cultural value. It seems to me that any change in the direction of meeting the needs of students for cultural courses in physics must come very largely within the present scheme of courses, and any increase in the number of students studying physics must be a gradual one which represents a recognition on the part of the students that physics is important in their education, rather than a sudden change brought about by administrative fiat.

The chief point that I wish to make in this paper is that we can change the character of the present elementary college course in physics so as to make it more valuable to the student with only a general interest in science, and at the same time we can make this course retain its value as preparation for a vocation. We can get some idea of the changes necessary if we attempt to answer the question, "What is a cultural physics course?"

I shall try to allow those who are teaching such courses to answer this question. During the past few years there has grown up a small body of literature about cultural courses in science, in which some attention is paid to the aims of such courses. When these statements of aims are thrown together and boiled down, one finds that three general objectives emerge fairly clearly. I shall discuss briefly each of the three. A physics course is a cultural course if it succeeds at the following tasks:

(1) *To help the student to comprehend the modern scientific world-picture.* The scientific world-picture is the account the scientist gives of the nature of the external world. This is extremely important but very much neglected in American education. Our tendency is to avoid the semi-philosophical aspect of science. We do not find the time in our classes to talk with students about the nature of matter and energy, about atomic structure and photons. We do not like to discuss the validity of physical theories and laws. We force a student to work through an arid chapter on rotational motion and then we fail to make the application to whirling electrons and rotating galaxies. We are so anxious to explore the minutiae of physics that we forget the need and the desire of the student for the bird's-eye view.

In America nearly all of the questions which an intelligent student naturally asks concerning the nature of the physical world go unconsidered in the physics classroom. Every society gives to its members a world-picture which forms a sort of background for their philosophies of life. In the modern society, the scientist has fallen heir to the duty of depicting the world-picture and interpreting it to the oncoming generation.

(2) *To help the student to see the advantages and the disadvantages of the applications of physical science in the modern world.* We all recognize the importance of applied science in the modern world, and we want our students to understand its power for good and for evil. But we do not touch upon these topics in our physics courses. We leave that to the social scientist. Now it is a question how far we should carry our study of the social and moral effects of applied science into

the physics classroom, but if we do not consider these things at all it seems that a dangerous compartmentalization may take place in a student's mind when he is led to study science divorced from its social effects in one college course and the effects divorced from science in another. Certain it is that a physics course would gain in interest and meaning to a student if it gave some consideration, at least through collateral reading, to the effects of the application of physics in modern life.

(3) *To help the student to appreciate the nature of scientific method and its possibilities and limitations.* This is a thing we talk about very much but handle very ineffectively in our physics courses. The scientific method is certainly not encouraged in the type of laboratory work we prescribe and in the kind of performance we permit in most of our elementary courses. The ordinary student gets no insight at all into the possibilities of this method. I believe that one reason so many of our most clever and facile-worded students become fiery denouncers of anything "scientific" is that they have formed their notions of science and scientific method from experience in these elementary science courses. If the term "scientific method" is to become something which has meaning for a student and which stands for a method of attack upon problems in which he has faith, it must be illustrated more clearly in his science courses. The program of laboratory work in elementary physics should be reconsidered with this aim in view.

Thus the idea that I wish to stress is that in order to develop the orthodox elementary physics course into something of more cultural value we must pay more attention to three things; the physical world-picture, the effects of applied science upon human living, and the scientific method. If we do that successfully, we shall have a cultural course which may play a valuable part in the general education of college students.

There is one thing to be added. Such a course would be valuable for the student who intended to make a vocational use of science, but it would not be sufficient because there would of necessity be omitted from it some of the detailed treatment of certain aspects of physics now considered essential in the elementary course. For such students it should be possible to arrange some extra work, possibly one laboratory period a week or something of that nature, as a means of helping them to master more of the information and techniques they will need in their work as scientists.

THE secret of education lies in respecting the pupil.—R. W. EMERSON.

IT does not take an idea so long to become 'classical' in physics as it does in the arts.—KARL K. DARROW, in *Electricity in Solids*, Bell. Sys. Tech. J. **3**, 621 (1924).

ON the whole the object of reflection is invariably the discovery of something satisfying to the mind which was not there at the beginning of the search. There is no fundamental difference between this discovery and scientific invention. "How did you discover the law of gravitation?" somebody once asked Newton. "By thinking about it all the time," was the answer.—ERNEST DIMNET, in *The Art of Thinking*.

Theory of the Reduction of Acceleration Data[1]

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The common methods of treating acceleration data in the student laboratory are discussed and the relative probable errors due to the random character of the spark are analyzed theoretically. Time intervals are assumed free from progressive or cumulative errors. A general formula is obtained which, if used properly, not only gives more reliable results but simplifies calculations. The proper use of the formula is determined for the general case.

THE development of frequency-controlled circuits and spark recording devices has made possible precise measurements of short time intervals and given a new impetus to acceleration measurements in the general laboratory. Due, however, to the random character of the spark and the inefficient methods commonly used in reducing the data, the expected accuracy in the measurement of acceleration has not been attained. Let us then examine the methods in common use, the analysis of which leads to a general formula not only capable of giving more accurate results than have been generally obtained, but also capable of being applied more simply from the standpoint of actual calculation.

Throughout our entire discussion we shall let t represent the time per spark interval. Then if s_1, s_2, s_3, s_4, etc., represent distances traversed during these equal time intervals, $s_1=v_0t+\frac{1}{2}at^2$, $s_2=v_1t+\frac{1}{2}at^2$, and subtracting, $s_2-s_1=(v_1-v_0)t$. But $(v_1-v_0)=at$; hence $a=(s_2-s_1)/t^2$, or in general $a=(s_n-s_{n-1})/t^2$. Until recently, this formula has been applied directly, and on obtaining the average of the first nine "observations," the experimenter obtained a result which may be symbolically expressed by

$$\bar{a}=[(s_2-s_1)+(s_3-s_2)+(s_4-s_3)+(s_5-s_4)+(s_6-s_5)+(s_7-s_6)+(s_8-s_7)+(s_9-s_8)+(s_{10}-s_9)]/9t^2, \quad (1)$$

which is only equal to $(s_{10}-s_1)/9t^2$. That is, the final result of a considerable amount of labor expended in collecting data and in making calculations was merely what would have been obtained by dividing the difference between the nth and the first space interval by $(n-1)$. Each of the individual terms in the numerator of Eq. (1) is the acceleration in centimeters per spark interval per spark interval, but the numerator of the result expressed in readings of the fixed scale is $(R_{10}-R_9)-(R_1-R_0)$, which is evidently the acceleration per one-spark interval per nine-spark interval; or the numerator might appear in the algebraically identical form $(R_{10}-R_1)-(R_9-R_0)$, in which case it represents the acceleration in centimeters per nine-spark interval per one-spark interval.

An improvement on this method led to the separation of the s's into two groups of equal size, in the foregoing case s_1 to s_5, and s_6 to s_{10} inclusive. Then s_6-s_1 represents the acceleration in centimeters per one-spark interval per five-spark interval, and the acceleration in centimeters per second per second is $a=(s_6-s_1)/5t^2$, $(s_7-s_2)/5t^2$, etc. The average of the five possible observations gives

$$\bar{a}=[(s_6-s_1)+(s_7-s_2)+(s_8-s_3)+(s_9-s_4)+(s_{10}-s_5)]/5\times 5t^2,$$

which might have been written in the form

$$\bar{a}=[(s_6+s_7+s_8+s_9+s_{10})-(s_1+s_2+s_3+s_4+s_5)]/5\times 5t^2.$$

[1] Read before the American Association of Physics Teachers at Atlantic City, December 29, 1932.

Perhaps a more common procedure has been to make the individual terms of the numerator the acceleration in centimeters per five-spark interval per one-spark interval. Though different in form, the expressions in terms of scale readings are algebraically identical as we have already seen in a similar case, and the result is merely the homogeneous expression,

$$\bar{a}=[(R_{10}-R_5)-(R_5-R_0)]/5\times 5t^2.$$

Again the whole experiment represents only a single observation, but taken over two consecutive five-spark intervals. It is a much better observation than that obtained by the first method.

In either of the methods discussed only four of the eleven readings are really significant (in the latter case three, since one enters twice). This fact has led to a variety of attempts to make all readings significant, among the most recent of which have been certain "skip" methods. By using one of the best of these methods with our assumed ten-interval set of readings,

$$a=\frac{s_6-s_1}{5t^2},\qquad a=\frac{s_8-s_3}{5t^2},\qquad a=\frac{s_{10}-s_5}{5t^2}.$$

For the average,

$$\bar{a}=[(s_6+s_8+s_{10})-(s_1+s_3+s_5)]/3\times 5t^2,$$

or expressed as scale readings,

$$\bar{a}=[(R_6-R_5+R_8-R_7+R_{10}-R_9)$$
$$-(R_1-R_0+R_3-R_2+R_5-R_4)]/3\times 5t^2,$$

in which every reading is significant; and with the exception of the R_5 which has double weight, all have equal weight.

But let us determine the relative probable errors of the three methods so far presented. The spark has a random character and this introduces a probable error e into each of the four readings which constitute an observation. Hence the probable error per observation will be some constant function of $(4e)$ divided by t^2 and two additional factors, say y and z. The probable error per observation may then be written $\text{P.E.}=f(4e)/yzt^2=E/yz$, where E is written for the constant portion $f(4e)/t^2$, assuming uniformity in the time intervals. The probable error of the average of x such terms will be $\overline{\text{P.E.}}=E/yz(x)^{\frac{1}{2}}$. Thus in the first method where there were nine observations, the probable error of the average would be $E/1\times 1(9)^{\frac{1}{2}}=0.33E$, if all observations were independent; however, since they may be written identically as a single observation with denominator $1\times 9t^2$, the probable error of the average is only $E/9=0.11E$, showing the increased accuracy due to the mutual cancellation of many of the observational errors. Similarly the probable error per observation in the second method is $E/5$, and for the five possible observations would be $E/5(5)^{\frac{1}{2}}=0.09E$ if all observations were independent; but it is only $E/5\times 5=0.04E$ for the single observation which is algebraically identical with the average of the five. Now in the skip method where all observations are independent, the probable error per observation is $E/5$, and for the three possible observations, $\overline{\text{P.E.}}=E/5(3)^{\frac{1}{2}}=0.11E$, showing that the accuracy of the method is low. Obviously, too, five observations instead of three might have been obtained without affecting the probable error per observation, by the simple expedient of shifting the position of the meter stick between the pairs of readings for the terminal points of each successive space interval. Such procedure is obviously improper, and no further consideration will be given to skip methods.

Lest this whole analysis seem concerned with an unimportant source of error, let us consider a case using the second method of reducing the data, which method is the most reliable of those in common use. With the Behr Free-Fall Apparatus there are never obtained more than fourteen spark intervals of one-thirtieth second each. The average of all the observations secured by the method is algebraically identical with $g=[(R_{14}-R_7)-(R_7-R_0)]/7^2t^2$, the numerator of which has a value of about 60 centimeters. Now if the readings R_{14} and R_0 happen to have errors which offset each other, and R_7 has an error of a millimeter and a half which is not unusually large, an error of one-half percent is thereby introduced into the final result. If the errors in R_{14} and R_0 happen to be cumulative, the resultant error may easily approximate one percent. It is therefore evident that the errors due to the random character of the spark are responsible for the disappointing results often obtained.

It is now clear that the best single observation

possible is

$$a=[(R_{10}-R_5)-(R_5-R_0)]/5\times 5t^2,$$

since 5×5 is the largest product of yz obtainable with a ten-spark interval; that is, with $N=10$. The equation might have been written in the form

$$a=[(R_{10}+R_0-2R_5)]/5^2t^2.$$

If the total number of spark intervals had been 11, ($N=11$) instead of 10, an equally good observation would have been possible in

$$a=[(R_{11}-R_6)-(R_6-R_1)]/5\times 5t^2,$$

or in the condensed form,

$$a=(R_{11}+R_1-2R_6)/5^2t^2.$$

The general form is evidently

$$a=(R_n+R_m-2R_{(n+m)/2})/[(n-m)/2]^2t^2,$$

where in successive observations m takes on the value 0, 1, 2, 3, etc., and n similarly increases from an initial even integer. This meets the obvious requirement that $(n-m)$ be even and constant for a given series. It will be seen that this formula includes as special cases both the first and the second methods; in the former case $(n-m)=2$, with nine observations possible, while in the latter case $(n-m)=10$, with but a single homogeneous observation possible when $N=10$. That is, the two extreme cases in the application of this formula have been used, neither of which gives the most accurate result which the data afford. Let us then determine the optimum value of the quantity $(n-m)$ for our assumed ten-spark interval. (Table I.) We see that for the case of $N=10$, the least probable error of the result occurs when $(n-m)=8$. If N were odd, or a larger even number, the advantage in probable accuracy of the favored value of $(n-m)$ over the two extreme values of $(n-m)$ that have been used in haphazard methods would be more conspicuous. The three observations possible for the optimum value of $(n-m)=8$ for our assumed case of $N=10$ are

TABLE I. *Optimum value of the quantity $(n-m)$ for a ten-spark interval.*

Value of $(n-m)$	Possible No. of obs.	P.E. per obs.	No. of independent obs.	P.E. for each independent obs.	P.E. of av.
2	9	$f(4e)/1\times 1t^2=E$	1	$E/9$	$0.11E$
4	7	$f(4e)/2\times 2t^2=E/4$	2*	$E/2\times 7$	$0.05E$
6	5	$f(4e)/3\times 3t^2=E/9$	3*	$E/3\times 5$	$0.0385E$
8	3	$f(4e)/4\times 4t^2=E/16$	3	$E/16$	$0.036E$
10	1	$f(4e)/5\times 5t^2=E/25$	1	$E/25$	$0.04E$

* The general method of determining the number of independent observations and their form is shown in the next paragraph.

$$a=(R_8+R_0-2R_4)/4^2t^2,\qquad a=(R_9+R_1-2R_5)/4^2t^2,\qquad a=(R_{10}+R_2-2R_6)/4^2t^2,$$

which contain all scale readings except R_3 and R_7. Though R_4, R_5 and R_6 each have double weight, all observations are independent. Since the observation obtained when $(n-m)=10$ is the best single observation possible, it might seem that the result of this observation should be averaged in with the other three. To do so would however give very excessive weight to the reading R_5 and would be further objectionable because it would destroy the symmetry of the series.

Let us now investigate the method of determining the number of independent observations to which the average of any series of observations can be reduced. We have already seen two simple illustrations of such transformations. As a third illustration, we shall determine the number of independent observations for the case of the seven observations when $(n-m)=4$ (see Table I). These appear in the average,

$$\bar{a}=[(R_4+R_0-2R_2)+(R_5+R_1-2R_3)+(R_6+R_2-2R_4)+(R_7+R_3-2R_5)+(R_8+R_4-2R_6)$$
$$+(R_9+R_5-2R_7)+(R_{10}+R_6-2R_8)]/7(2\times 2)t^2.$$

The denominator, $7(2\times2)t^2$, which here appears, indicates that the numerator is the sum of seven terms each of which is the acceleration in centimeters per two-spark interval per two-spark interval. A change in the order of the factors in the denominator gives $2(2\times7)t^2$, which implies that the numerator might be written as the sum of two terms each of which is the acceleration in centimeters per two-spark interval per seven-spark interval. This we find to be true, for we may write as an algebraically identical expression

$$\bar{a}=\{[(R_9-R_7)-(R_2-R_0)] \\ +[(R_{10}-R_8)-(R_3-R_1)]\}/2(2\times7)t^2.$$

In general, if the denominator is of the form $x(yz)t^2$, the corresponding numerator has for its first term,

$$[(R_{N+1-x}-R_{N+1-x-y})-(R_{N+1-x-z}-R_{N+1-x-z-y})].$$

Since the subscript of the last R in the expanded form of the first term must always be zero, we see that $x+y+z=N+1$. Evidently the denominator cannot be refactored, since both the product and the sum of the factors must be constant; but for any change in the order of the factors of the denominator, a corresponding numerator can be written without loss of its algebraic identity. Clearly if these terms in the numerator are to be independent, they must consist of the smallest number possible; that is, x must be the smallest of the three factors x, y and z.

We shall now establish the most favorable value of $(n-m)$ for the general case. The probable error per observation in the general case is $f(4e)/yzt^2=E/yz$. If for the moment we limit our consideration to homogeneous observations where $z=y$, the probable error per observation is E/y^2. The probable error for the average of x observations all of which are independent, is $\overline{\text{P.E.}}=E/y^2(x)^{\frac{1}{2}}$, which is least when $y^2(x)^{\frac{1}{2}}$ is a maximum, or when y^4x has its maximum value. Substituting from $x+2y=N+1$, the probable error will be least when $(N+1)y^4-2y^5$ is a maximum. Differentiating, we see that the most favorable value of y is $(4/10)(N+1)$. Perhaps, however, in the most general case, z does not equal y. But since any two numbers y and z whose sum is constant will have their maximum product when their values are equal, it follows that we already have the most general case. Now y is merely our quantity $(n-m)/2$, and therefore the most favorable value of $(n-m)$ in the general case is $0.8(N+1)$. In applying this result, we must take for $(n-m)$ the even integer most nearly equal to $0.8(N+1)$, so that the value of $(n-m)$ must always lie within the range $0.8(N+1)\pm1$.

In establishing the most favorable value of $(n-m)$ in the general case, we assumed that the series of equations representing observations thereby established would always be independent. This point should now be tested. As the number of spark intervals available becomes larger, the number of equations obtainable increases correspondingly until the quantity $(n-m)$ makes a jump to the next even integer. For example, if N increases from 10 to 11 in the special case we have investigated, the observation represented by $a=(R_{11}+R_3-2R_7)/4\times4t^2$ would be independent, but if N should further increase to 12, the added equation would not be independent, for it would contain R_4 and R_8 both of which would have been used in the first of the series of observations. But neither of these equations would be written, for if R_{11} exists, 0.8 $(N+1)$ is more nearly equal to 10 than to 8, and hence the most favorable value of $(n-m)$ for the series is not 8 but 10. Inspection shows that the first $(n-m)/2$ equations of any series will be independent, since the equations will all be independent until the value of x exceeds that of y. The number of equations obtainable in the general case is $x=N+1-2y$, so that the maximum number of equations obtainable in any case cannot exceed $0.25(n-m)+1.25$. Accordingly it is only in the case of small values of $(n-m)$ that we need be on guard for equations which are not independent. Inspection shows that for any number of spark intervals greater than four, all equations obtainable by the proposed method are independent. For even values of N less than ten, our method degenerates to give the same result as the second method, since the optimum value of $(n-m)$ becomes equal to N; but for all odd values of N, and for all even values of N greater than fourteen, our method reduces the probable error of the result by twenty-five percent or more. In cases where there are a very large number of spark intervals, the rigorous application of the above theory would yield an ex-

cessive number of observations. The reliability of the apparatus would seldom seem to warrant more than perhaps six observations. Instead of taking $(n-m)$ equal to 0.8 $(N+1)$, it may then well have a lower limit of $(N-5)$.

One other source of error demands consideration. In some spark timers alternate spark intervals differ quite considerably. No error is thereby introduced if $(n-m)/2$ is even, for in that case there is the same number of long and short spark intervals in each of the spaces whose difference determines an observation. If $(n-m)/2$ is odd, the individual observations will obviously be more divergent, but even yet no error is thereby introduced into the average provided there is an even number of consecutive observations.

While this discussion has been confined to the measurement of linear acceleration, it is evidently equally appropriate and the results equally general for the determination of angular acceleration.

ANGLING may be said to be so like the mathematics that it can never be fully learnt.—IZAAK WALTON, in *The Compleat Angler*.

VERY late in life, when he was studying geometry, some one said to Lacydes, "Is it then a time for you to be learning now?" "If it is not," he replied, "when will it be?"—DIOGENES LAERTIUS, in *The Lives and Opinions of Eminent Philosophers*.

AN engineer is a man who knows a great deal about a very little, and who goes along knowing more and more about less, until finally he knows practically everything about nothing. A salesman, on the other hand, is a man who knows a very little about a great deal, and keeps knowing less and less about more, until finally he knows practically nothing about everything.—Union Oil Bulletin.

ABOVE all I wish to oppose the now widespread and seemingly plausible opinion, that a question in physics is only worth investigation if from the outset the fact that it admits of a definite answer is established. If the physicists had always followed this precept, the celebrated experiment of Michelson and Morley on the measurement of the so-called absolute velocity of the earth would never have been made. . . . So our efforts to ascertain the absolute velocity of the earth have proved exceedingly fruitful for science, although nowadays the question itself is almost universally considered to be meaningless.—MAX PLANCK, in *The Concept of Causality*, Proc. Phys. Soc. September 1, 1932.

New Developments in Apparatus for the Elementary Laboratory

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In considering the adoption of a piece of apparatus for use in a general physics laboratory, some of the principal factors to be considered are as follows:

(1) The clearness with which it illustrates a given physical principle.

(2) The interest which it arouses in the student.

(3) Its cost. This factor should include both the initial cost of the apparatus and its maintenance. The latter involves not merely ruggedness but also simplicity and the convenience with which it may be made ready for student use.

The apparatus described in this paper has been developed at the University of Pittsburgh with these factors in mind.

The Mechanical Advantage and Efficiency of an Automobile Transmission

Most students have a slight knowledge of the construction of an automobile transmission, yet few have ever examined one closely. The use of this machine in the laboratory arouses their interest and thus facilitates instruction.

In the apparatus shown in Fig. 1, the housing of a standard automobile transmission is partly cut away, thus exposing the working parts. An "input" pulley A is mounted on the engine shaft and another, B, of equal diameter, is mounted on the drive shaft.

In performing the experiment, the student first counts the number of teeth on each cog wheel and records the data on a rough sketch of the gear assembly. With the gear shift lever in a chosen position, the velocity ratios of the several pairs of gears are computed from the respective numbers of teeth. From these ratios, the "overall" velocity ratio is calculated. As a check on the value, this ratio is determined by counting the number of revolutions of the "input" pulley which corresponds to one revolution of the "output" pulley. The reciprocal of the velocity ratio equals the "frictionless" mechanical advantage. The latter may also be determined by attaching a weight W to a string wound on the output pulley and finding the mean of the two weights on the input pulley which cause W to move first upward and then downward, with uniform speed. The actual mechanical advantage (with friction) is given by W/W_i, W_i being the weight on the input pulley required to produce uniform upward motion of W. The efficiency E is determined by means of the equation $E=WR/W_i$, R being the velocity ratio.

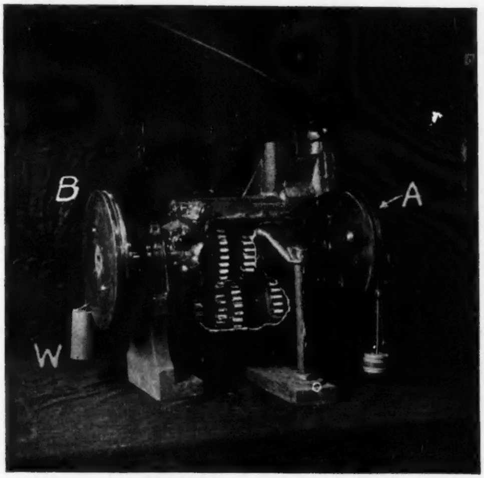

Fig. 1. Method of determining the mechanical advantage and efficiency of a standard automobile transmission.

A second-hand Chevrolet or Austin transmission, costing about five dollars, serves admirably for the apparatus. About eight hours are required for cleaning and shop work.

The Mechanical Equivalent of Heat

Accurate measurements of the mechanical equivalent of heat are difficult with the commonly used apparatus in which the heat is gen-

erated between two concentric cones. Students often lose time because they have difficulty in turning the hand-wheel at a rate just sufficient to balance the free weight. This is especially true after the surfaces become worn; since, under such circumstances, the frictional force becomes very erratic. Also, since the mass of material heated is small, large errors are likely to occur unless the mass of water is measured very carefully. To eliminate these disadvantages and at the same time make a very rugged device of neat appearance, the apparatus in Fig. 2 was constructed.

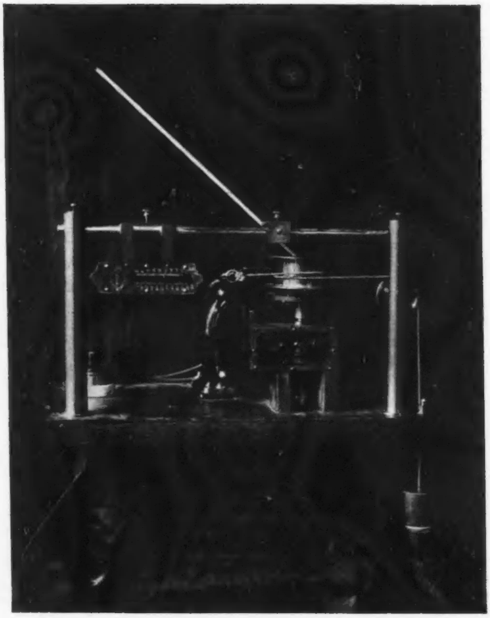

FIG. 2. Rugged and compact device for measuring the mechanical equivalent of heat.

This device, which to a certain extent is a modification of the Cambridge type, consists of a brass drum about 10 cm in diameter. The drum rotates about a vertical axis and contains about 300 g of water. It is fastened by means of thumb screws to a Bakelite disk driven by an electric motor through a worm gear with a 5 to 1 reduction. This Bakelite disk serves to heat-insulate the drum from the rest of the apparatus. A revolution counter is attached to the lower end of the vertical axle.

A belt or cord is wrapped around the drum. One end of the belt is fastened to a spring balance held by a horizontal rod. The other goes over a pulley in one of the supports and carries a weight. The horizontal rod also supports the thermometer which acts as a stirrer as the drum rotates. With a load of two kilograms on the free end of the belt, the temperature rise is about one degree per minute with a speed of rotation of the drum of six turns per second.

The mass of water heated is comparatively large. To avoid the necessity for large changes in temperature, a thermometer reading directly to one-tenth degree is used. It is found that a change of from about 5 degrees below room temperature to 5 degrees above is suitable, and gives a result which is usually accurate to about one percent. In calculating the mechanical equivalent, the quantities that enter are the mass of water, the mass, specific heat and radius of the drum, the total number of revolutions, the difference between the load on the cord and the reading of the spring balance, and finally, the change in temperature.

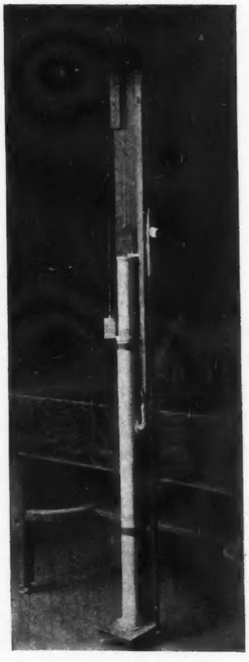

FIG. 3. Resonance apparatus with metal tubes and counterpoise.

A Rugged and Convenient Resonance Tube

Resonance tubes for laboratory use frequently consist of two concentric glass tubes, the outer of which is filled with water. Such an arrangement is very fragile. To secure greater ruggedness, the outer tube is sometimes made of metal. In this case, the elevation of the water is observed through a glass window mounted in the wall. This device is of limited desirability since the window is liable to leakage. In the arrangement shown in Fig. 3, two pieces of galvanized iron or copper rain-spouting are used, which are respectively 3 inches and 2 inches in diameter. The larger tube is closed at the bottom and is mounted on a vertical board.

A standard $\frac{3}{8}$-inch gas pipe, fastened to one side, supports an "ell" and a vertical nipple in which a glass tube is mounted. This tube serves to indicate the elevation of the water in the large pipe. The smaller tube is supported by a cord with a counterweight, so that the length of the resonance column may be varied. The elevation of the upper end of the tube may be read from a scale.

A Simple Radio "Hook Up"

Laboratory experiments in radio frequently fail because the voltmeters, ammeters, and switches are so numerous that the beginner in physics is confused. After several years of trial and error, an arrangement has been evolved in which instruments and switches have been reduced to a minimum. The apparatus (Fig. 4) is mounted on a horizontal, 6×8-inch Bakelite panel. A massive brass strip *G* is fastened along one edge of the panel and serves as a "ground." The necessary parts include a battery-type radio tube *A*, an inexpensive radio milliammeter *B* and an ordinary slide wire rheostat[1] *R*. This rheostat is used as a potential divider or "potentiometer," a scale being engraved on the slider arm *C*. When the rheostat is connected across a 115-volt d.c. line, this scale indicates for any slider position the approximate potential difference between the plate and the grounded end of the filament in the radio tube. The grid potential may be varied by connecting from one to four dry cells in series between the ground and the grid binding post *D*. To prevent damage if these cells are accidentally connected to the filament of the tube, they are mounted in a box and small 20-ohm resistors *E* are connected between adjoining cells. No voltmeter is used, the potential difference being taken as equal to the sum (positive or negative) of the e.m.f.'s of the cells connected to the "grid."

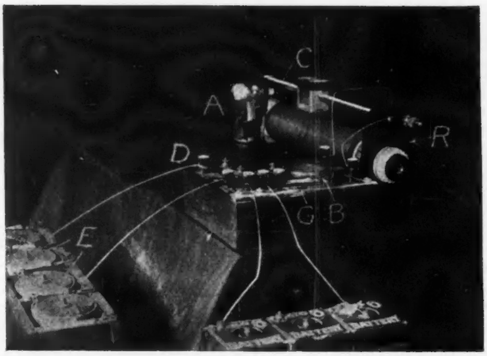

Fig. 4. Simple assembly for finding the characteristics of a radio tube.

Three experiments are usually performed in a two-hour period, namely: (1) The determination of two (plate current)-(plate voltage) curves, one at normal filament voltage, the other at a reduced voltage obtained by connecting the wire from the positive battery terminal to a third binding post which leads to the filament through a 5-ohm resistor; (2) The determination of a (plate current)-(grid voltage) curve with normal filament voltage; (3) The determination of the amplification constant from the ratio of the change in plate potential required to cause a small increment in plate current to the change in grid potential to cause the same increment.

The cost of this apparatus, not including the slide wire rheostat, is about five dollars. About six hours of shop work are necessary for construction.

[1] In most laboratories, considerable inconvenience and expense arises from accidental overloading of ammeters and rheostats. Fuses on such instruments are both economical and convenient. The ordinary screw-plug type is preferable to the cartridge type because damage to the fuse may be detected at a glance. A simple and convenient mounting of a fuse receptable on a slide wire rheostat is shown in Fig. 4. The fuse is connected in series with the slider bar of the rheostat to prevent the possibility of a "burn-out" when the slider is near one end and large current is being drawn.

A Convenient and Inexpensive Mercury Arc Lamp Assembly

In diffraction experiments, a convenient and intense source of line spectra is needed. In using direct-current mercury arc lamps, trouble often arises because of accidental reversal of current through the lamp. Also, in starting such a lamp, it is necessary to reduce the external resistance.

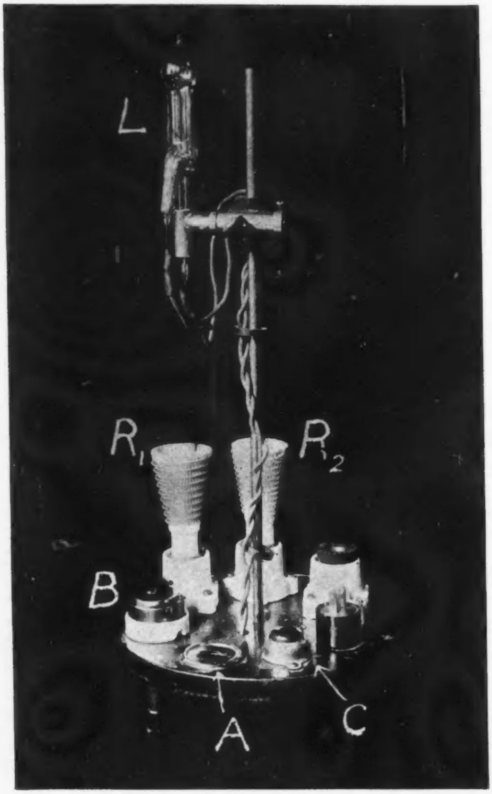

Fig. 5. Mercury arc lamp assembly for diffraction experiments.

Sometimes the operator forgets to increase this resistance after the normal operating temperature is attained. These difficulties have been eliminated by a convenient and inexpensive arrangement as follows.

[2] The writers do not know to whom credit is due for the fundamental design of this lamp. It has been used in this country for several years, and may be purchased from the Pittsburgh Engineering Company, Swissvale, Pa. For a description, see T. H. Osgood, J. Sci. Inst. 5, No. 10, (1928).

The lamp[2] L (Fig. 5) is mounted on a rod supported by an ordinary clamp stand.[2] The necessary resistances, etc., are supported on a wooden platform. The current flows through a Ford ammeter A, a snap switch B, two resistors R_1 and R_2, and thence to the mercury lamp. The ammeter indicates whether or not the current flows in the proper direction. For starting the lamp, a push button[3] C, connected across the terminals of resistor R_2, serves to short circuit this resistance momentarily, thus increasing the voltage across the tube. The resistors R_1 and R_2 are respectively of 20 and 10 ohms resistance, and are of the type used in radiant heaters.

The cost of materials, including the lamp, is about nine dollars. The shop work requires about five hours.

A Simple Refractometer

The refractometer is widely used in measuring refractive indices of liquids and solids, and it seems desirable to illustrate the principle of this instrument in an elementary physics course. In addition, the phenomenon of total reflection excites the interest of students, many of whom have never observed it.

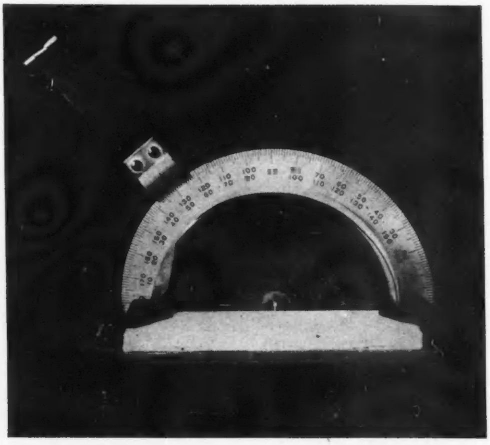

Fig. 6. Simplified critical-angle refractometer.

The device proposed here is a simplification of the Abbe refractometer. As shown in Fig. 6, it

[3] With ordinary push buttons, arcing is likely to occur, causing oxidation of the contacts. We have found that an ordinary tumbler switch with an additional spring to return the tumbler to an "off" position serves admirably.

consists of a white porcelain base and a removable semicircular piece of glass such as is used in the Hartl optical disk. Light is scattered by the white base, but in going from the air layer into the glass, it is refracted so that the angle of emergence is never greater than the critical angle. Thus if one observes the glass disk from one edge, the part above the critical angle appears white while the part below appears silvered because of total reflection. To read the critical angle, a protractor is attached. A sighting bar is mounted with its axis at the center of the circular scale of the protractor. A line is scratched across the lower flat surface of the semicircular disk at its midpoint, and clips are fastened to the base so that after the disk is removed it will always be replaced with the scratch along the axis of the sighting bar.

To use this apparatus, it is only necessary to place the disk in the clips and set the sighting bar so that a slit in its end is in line with the scratch and with the line of demarcation between the apparently silvered and the white edge of the disk. The critical angle is read from the protractor, and the relative refractive index of the glass with respect to air is computed. Having thus found the index of the glass, that of any liquid may be obtained by placing a thin film between the white base and the semicircular disk and repeating the previous procedure.

The authors realize that their colleagues at the University of Pittsburgh have contributed many helpful suggestions in the development of these devices, and express their appreciation for this aid.

THOSE volumes in which there is so much discussion of nature that it is no longer necessary to go and look at it.—PRINCESSE MARTHE BIBESCO, in *Egyptian Days*.

TO succeed in science it is necessary to receive the tradition of those who have gone before us. In science, more perhaps than in any other study, the dead and the living are one.—CHARLES SINGER.

ALMOST no advertising intended to influence the general public is honest in the sense that a decent scientist understands honesty.—ARTHUR KALLET AND F. J. SCHLINK, of Consumers Research, in *Advertising and Selling*, September 1, 1932.

EDUCATION does not mean teaching people what they do not know. It means teaching them to behave as they do not behave. It is not teaching the youth the shapes of letters and the tricks of numbers, and then leaving them to turn their arithmetic to roguery, and their literature to lust. It means, on the contrary, training them into the perfect exercise and kingly continence of their bodies and souls. It is a painful, continual and difficult work to be done by kindness, by watching, by warning, by precept, and by praise, but above all—by example.—JOHN RUSKIN.

APPARATUS, DEMONSTRATIONS AND LABORATORY METHODS

Animated Blackboard Diagrams[1]

As we have viewed teaching films we have been impressed with the effectiveness of animated diagrams. At the same time we have seen the difficulty and expense of fitting these animations into our own courses. We have therefore been induced to experiment with making them. We discovered this summer that they can be made rather easily, contrary to our previous understanding that the process would require technical skill as well as time and expense.

In leisure time this fall we have made and photographed seven brief projects. The steam engine was the second subject attempted; it required 100 complicated drawings on paper and 2 drawings on celluloid. The motion is quite jerky and irregular but in later work this is largely avoided by improvements in the method. In a study of projectile motion 216 simpler drawings on paper and one celluloid required 24 hours. Drawings to show the effect of a charged body on a charged electroscope were made later by a university freshman in 8.5 hours, including the time required to plan the project and to practice drawing on the celluloid. An animation of simple harmonic motion was completed in about 4 hours. The total length of film used has been 156 ft. The cost of supplies, not including any permanent equipment, has amounted to about $12.00, nearly all of which has been spent for film.

Our method resembles that used in making animated cartoons. A detailed description of it has been given elsewhere.[2] It consists of drawing stationary parts on celluloid while moving parts in successive steps of the motion are drawn on separate sheets of paper. To obtain the correct relative positions in all drawings, these are copied from the same original work-sheet, by using a tracing board with a glass window and with two pegs set in it, and by using paper and celluloid specially punched to fit these pegs. The drawings are then photographed in correct sequence with a 16-mm amateur motion picture camera, taking from one to three pictures of each drawing. In doing this use is made of what is known as a title-writing set, a standard piece of equipment by means of which an amateur may photograph his own titles. Fig. 1 shows the adopted title-

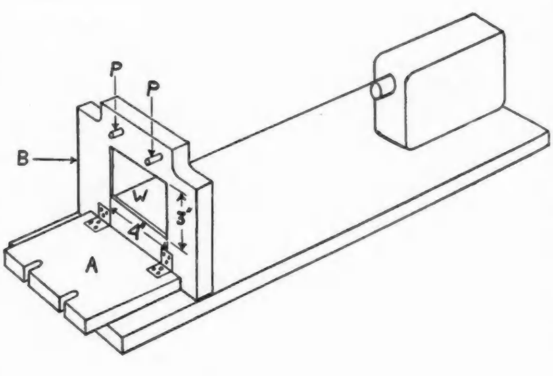

FIG. 1. Title-writer.

writer; correct alignment of the celluloid with the sheets of paper is secured by the pegs *P*, *P*, which are spaced at exactly the same distance as are those of the tracing-board. Fig. 2 gives the work sheet for a study of the motion of a projectile. Fig. 3 shows examples of the drawings on paper for the same project, giving respectively the thirtieth drawing of the actual path of the projectile, the thirtieth drawing of the motion as it would be without the action of gravity, and the

[1] Read before the American Association of Physics Teachers at Atlantic City, December 31, 1932.

[2] R. L. Petry, Educ. Screen 12, 5–7 (1933).

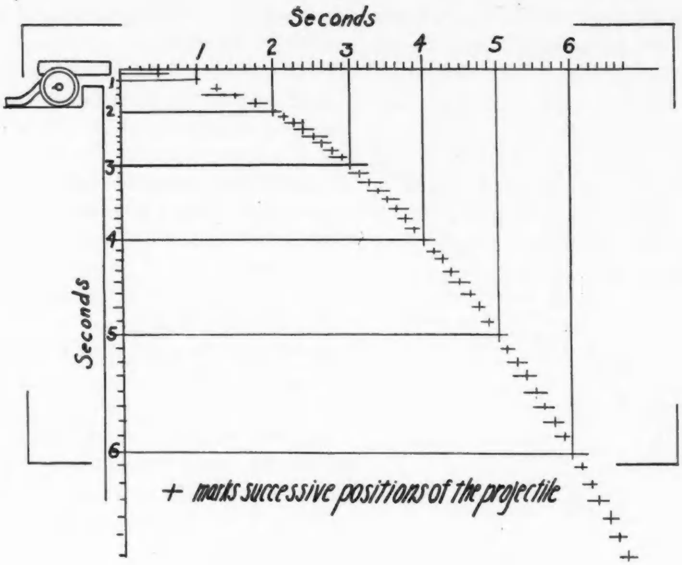

FIG. 2. Work-sheet, showing the plan and measurements for a study of the motion of a projectile.

fortieth drawing of the motion in a parabola as the resultant of uniform motion in a horizontal line without gravity and of uniformly accelerated motion in a vertical line under gravity alone.

We have chosen the title *Animated Blackboard Diagrams* because we wished to emphasize the simplicity of these drawings and their relationship to the blackboard rather than to the conventional motion picture screen. These films represent preliminary results and are obviously experimental but they have advantages which may compensate for some of their limitations. It is to be understood that in what follows we are considering not so much any of the films which we have made as those which any teacher might make individually in his own way for his own use.

In the first place, by this method films can be made to visualize for the student motions which formerly had to be explained with expensive working models or with blackboard diagrams and word pictures. However, we have not intended to use motion pictures in any cases in which the actual equipment and demonstration can be shown at all readily, but only in cases where the pictures have unique advantages because of slowing up or speeding up motion, enlarging or reducing the size of apparatus, or saving a great amount of time in explanation of motions or in preparing demonstrations.

But at the same time they can be made to aid the lecturer in much the same way as any other piece of demonstration apparatus. That is, since they are planned by the teacher himself they will fit into his lecture rather than interrupt it. It is obvious that such brief films are intended to supplement the lecture rather than to supplant it; at the same time their brevity and their limitation to one topic will tend to concentrate the student's attention upon a single phase of a subject instead of scattering it as may be done when too many topics, even if closely related, are presented in a short time.

In the third place, the cost of making these films is low enough and the method is so simple that anyone can afford to experiment with diagrams of this nature. This is of special importance because the production of teaching films, like many other scientific developments, may have to pass through an amateur stage before teachers in general will appreciate the advantages of motion pictures. At present there are too many able and expert teachers who have lacked an op-

portunity to contribute their ideas as to the best use of motion pictures in teaching. As a result these people have lacked, and still lack, constructive interest in films. Possibly the best means of arousing the latent interest of these teachers and of drawing out their original and constructive ideas about the use of films lies in giving them the opportunity to participate by making motion pictures themselves, even if they make only a few feet of simple film.

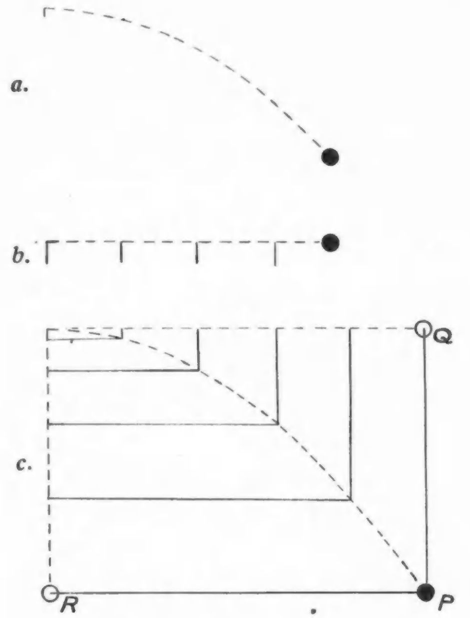

FIG. 3. Examples of the drawings on paper.

In making these films most of the work consists in planning and in making the drawings and not in photographing them. Because of this, plans could be formulated by which one person could do the photographing for a number of others. Then each of the latter would need only a tracing-board and a small projector for his own use. For use with small classes of 20 or less the smallest projectors are fairly satisfactory for introductory and experimental work of this kind. Also sometimes a cyclic subject does not require more than 6 to 8 ft. of film, or 15 to 20 seconds, per cycle. In cases of this kind the ends of the section of film may be spliced together to form a closed loop which may be run continuously through the projector as many times as may be desired. The cost of each loop of a project is then very low, between ten and fifty cents. With loops of this kind and with an inexpensive projector—good used projectors may often be obtained at a considerable reduction—motion pictures may be used over and over by the student for review purposes with very little supervision. (It must be noted that for using loops a projector which can be threaded from the side as well as endwise is very advantageous; otherwise the film has to be spliced while in the projector each time it is to be used.)

To sum up, in cases where the use of films in any form might otherwise be deferred for a long time, this method offers a way of beginning a limited use individually, of beginning it promptly and inexpensively, and of continuing it cumulatively and effectively.

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University of the South
Sewanee, Tennessee

Increased Heat Emissivity Caused by Asbestos "Insulation"

IN spite of the experimental data[1] which have been available since 1920, it is still standard practice to cover bright "tin" and galvanized iron hot-air furnace pipes and casings with ten or twelve-pound asbestos paper, the object being to decrease the loss of heat from the pipes and casings.

The University of Illinois studies showed that the covering of a bright tin furnace pipe with a single layer of twelve-pound asbestos paper, in the

[1] *Emissivity of Heat from Various Surfaces,* Univ. of Illinois Eng. Exp. Sta. Bull. 117 (1920).

usual manner, causes more than a 60 percent *increase* in the loss of heat. They found that 7 layers of such paper applied to the pipe made the pipe retain its heat *almost* as well as did the bare bright pipe. Eight layers of the twelve-pound paper were found to make the pipe retain its heat only a little better than did the bare pipe. The relation between number of layers of paper and coefficient of heat emissivity was found to be roughly linear, the relative values of the emissivity for bright tin and the tin with one layer of paper being respectively 1.00 and 1.62.

Such valuable information is easy to present to students but it is a quite different problem to get them to really believe the facts in spite of careful qualitative explanations of the phenomena.

A very simple inexpensive apparatus was devised, which gives a convincing demonstration. The apparatus consists of two empty bright tin No. 2 or 2½ "tomato cans," one of which has its outside cylindrical surface covered with a single layer of ordinary asbestos paper, the paper being carefully pasted to the tin with asbestos cement. Covers for the cans may be made from two five-inch square boards, in whose centers are holes for cork stoppers through which pass thermometers.

The procedure is to pour boiling water first into the bright tin can and then, to the same height, into the asbestos covered can so that the container with the bright surface may have the advantage of a head-start. The cans are covered with the boards containing the thermometers and the indicated temperatures are noted from time to time. If the demonstration is started at the beginning of the class period, by the end of the hour the thermometer in the asbestos covered can will read 5 to 8°C *lower* than the one in the bright tin container.

The curves shown in Fig. 1 were obtained with

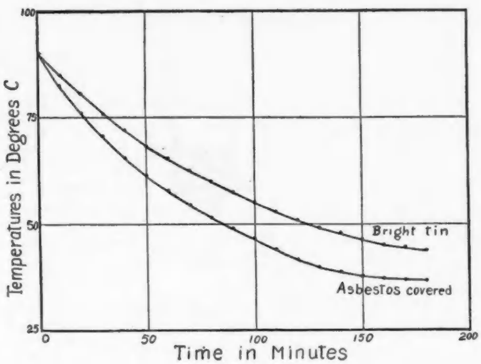

FIG. 1. Temperatures of the water in the two vessels as a function of the time of cooling.

two No. 2 cans, one of which was covered with one layer of twelve-pound asbestos paper. The pine covers which were turned on a lathe, had narrow grooves which allowed the tops of the cans to fit into the wood. The covers were also soaked in hot paraffin wax, which made them waterproof and thus prevented their warping.

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Department of Physics
University of Oklahoma

An Apparatus for Projecting Phonodeik Oscillations[1]

THE present method of setting up the arc lamp and rotating mirror for projecting phonodeik oscillations is clumsy and requires too much time. An attempt at improvement is suggested as follows. The phonodeik diaphragm is mounted permanently on the small end of a triangular metal base of isosceles shape (Fig. 1). At one of the other corners is a small concentrated filament lamp with a short-focus lens and at the third corner is a small octagonal rotating mirror mounted on cone bearings. The principal axis of the lens and the normals to the centers of the mirror lie in the same plane, so that the reflected spot of light moves in a straight path across the screen at all times. The lamp filament is run at maximum intensity and the octagonal mirror gives more light per foot of screen than does the four-sided type. The mirror is kept in rotation by placing the hand on the brace sup-

[1] Read before the American Association of Physics Teachers, Atlantic City, on December 29, 1932.

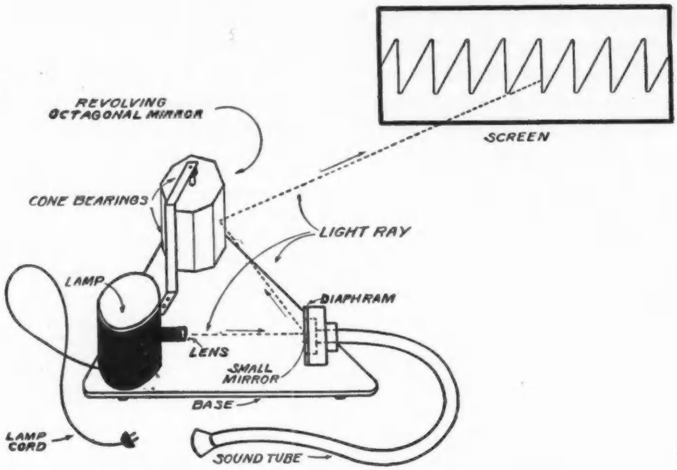

FIG. 1. Apparatus for projecting phonodeik oscillations.

porting the top of the mirror and spinning the small shaft between the fingers.

The mirror plates should be about 2.5 in. long and 0.5 in. wide. The base plate should have its equal sides about 10 in. in length and the remaining side about 8 in. in length. With this arrangement it is easily possible to project a wave form of amplitude 9 in. and length 12 ft. on the wall of the lecture room and, by properly controlling the speed, to make the wave from a tone of constant pitch progress, stand still, or recede.

J. G. BLACK,
Morehead State Teachers College

Brief Notices of New Publications and Teaching Aids

Jobs for the College Graduate in Science. EDWARD J. V. K. MENGE, Director of the Department of Zoology, Marquette University. Pp. 175+viii. The Bruce Publishing Company, Milwaukee, 1932. Price $2.00.

This book is intended primarily as an analysis of opportunities in the various sciences, pure and applied. It will be useful mainly to the student who has not selected his major field of study.

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Introductory Acoustics. GEORGE W. STEWART, Professor of Physics, University of Iowa. Second Edition. Pp. 200 +xi, Figs. 82. D. Van Nostrand Company, Inc., New York, 1933. Price $2.75.

The first edition of this book was reviewed in the February number of *The American Physics Teacher*. The new edition appears in cloth and contains an index of subjects.

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Composite List of Non-Theatrical Film Sources. Pp. 17. Motion Picture Division of the Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce, Washington, 1932. Price $0.10 (Paper cover).

This bulletin lists 524 concerns which have films for distribution, and indicates whether the films are available free of charge or otherwise, whether they are 16 or 35 mm in size, whether they are silent or sound, and whether or not they are printed on non-inflammable stock.

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One Thousand and One. The Blue Book of Non-Theatrical Films. NELSON L. GREEN, Chairman of the editors. Ninth edition. Pp. 128. The Educational Screen, Inc., Chicago, 1932. Price $0.75.

Available films are classified according to subject. Each film is reviewed briefly and its size, the number of reels and the name of the distributor are given.

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The Roll Control. A Motion Picture. 1 reel, silent, 30 min. running time, either 16 or 35 mm. Sperry Gyroscope Company, Brooklyn. Loaned free of charge.

A film in which is demonstrated the use of the gyroscope in stabilizing ocean-going vessels.

Informal Reports of Standing Committees of the American Association of Physics Teachers

The Committee on Differentiation in First Year Courses

THE members of the committee on differentiation in first year courses are: L. R. Ingersoll, University of Wisconsin, *Chairman;* F. L. Brown, University of Virginia; A. E. Caswell, University of Oregon; D. W. Cornelius, University of Chattanooga; H. C. Richards, University of Pennsylvania; W. W. Sleator, University of Michigan; T. R. Wilkins, University of Rochester; P. I. Wold, Union College; A. G. Worthing, University of Pittsburgh.

This committee has begun operation in a painless way—that is, without the use of questionnaires—by first taking stock of the situation in the institutions with which the members are connected. As will be noted from the membership of the committee the list includes a good variety of colleges and universities both large and small, totalling, when there are added two or three concerning which we also have information, an even dozen schools.

Perhaps we had better begin by defining some terms as we use them. By "differentiation" we refer to the offering by a department of a number of different courses, all essentially elementary in character, designed to meet the needs or preparation of different classes of students. In general these courses cover the whole field of physics, although with considerable variation in emphasis. By "first year" courses we mean first courses of distinctly college character. Courses of preparatory or high-school character—in general without college credit—are not included, nor are survey courses, unless limited to physics.

As already indicated, we may distinguish at least two types of differentiation. The one takes account of the previous training of the student—high-school physics or the lack of it, mathematical preparation, etc. The other aims to supply, by multiplicity of courses, the particular emphasis that various types of professional training seem to require. You will note that we say "*seem* to require" because there is no doubt at all that the requests for special courses in physics from professional schools and other departments frequently far exceed that which it is feasible or wise to supply.

Now it is possible, of course, to do away with any differentiation based on previous preparation by laying down hard and fast prerequisites, such as high-school physics, college algebra, trigonometry, analytic geometry, and in some cases even concurrent registration in calculus. The present tendency, however, is entirely away from such a rigorous set of requirements as applied to a general course in physics, although such requirements are fairly common for engineering courses. There is no general agreement as to the necessity of high-school physics as a prerequisite. In general, physics as taught in the high school does not seem to be any too highly regarded in college. The student who has had it finds college physics somewhat easier, of course, but its lack does not seem to offer any great difficulty to successful work in the college course. In some of our largest institutions there are no specific prerequisites either in mathematics or high-school physics, for the general course.

When it comes to meeting the needs, real or fancied, of different classes of students there are a large number of possible cases. Premedical, predental, engineering, home economics, physical education, agriculture, music, general, science major and physics major, are the commonest subdivisions looking for special courses or special treatment in courses. Undoubtedly the first of the above classes—premedical students—is the group about which most of the discussion on differentiation has centered. The general tendency seems to be distinctly *away* from any special course for this group. It is true that physics is quite commonly regarded by the premedical student as a hurdle which must somehow or other be cleared, and the degree of clearance is sometimes such as almost to require a micrometer

microscope for its measurement. By and large, however, there is a distinct feeling that if the future health of the country is to be entrusted to these embryo doctors, they must at least be capable of making good in the general course in physics, while some medical faculties want even stiffer requirements than the average for such a course. Small sympathy therefore will be felt for the institution which, as described in a letter from one who is almost the dean of American physics teachers, "had to give its premedical (physics) course so it could be followed by a young woman who entered on home economics and dressmaking with a condition in Algebra A, and had to be prepared for the Medical School in two years." My correspondent suggests that "the poor girl had started up the wrong educational tree and should either stay up there and make a nest for some happy man, or climb down and start over."

In the matter of engineering students the general feeling is quite different and is to the effect that here is a highly legitimate case for differentiation. Such students generally have had or are taking calculus and may well be expected to carry a more mathematical course than the general student. Home economics is perhaps the next group to be split off from the general course and here the situation is just the reverse of that in engineering, for such students, in common with perhaps majors in physical education and agriculture, have little mathematical training or interest.

The situation in a nutshell amounts to this: the larger the number of students of physics in an institution the more the differentiation. When the total number does not exceed 50 or even 100, there is seldom more than one course, although special laboratory treatment is always possible. As the numbers grow, however, one group after another is given a special course, usually beginning with engineering, followed by home economics, agriculture, etc. At the University of Wisconsin, where differentiation is carried farther than in any other institution so far studied, there are two general courses in physics, one of which is for science majors, two courses for different engineering groups, courses for home economics and agricultural students, a short special course for music students, and a survey course. Undoubtedly few would justify such a multiplicity of courses, at least in these lean years. However, it may be said that a careful study has failed to reveal any marked economies which could be effected by combination, considering the number of students involved.

The committee expects to extend its inquiries to many other institutions during the coming year. Its next report should embody something of a statistical study of the situation, and perhaps it may be able to make recommendations.

L. R. INGERSOLL, *Chairman*

The Committee on Visual Education

THE committee on visual education was organized during the latter half of 1932. The members of the committee are: O. H. Blackwood, University of Pittsburgh; Eric R. Lyon, Kansas State College of Agriculture and Applied Science; R. L. Petry, University of the South; W. S. Webb, University of Kentucky; F. J. Shollenberger, Mount Union College, *Chairman*.

Much time has been spent in endeavoring to collect available literature which may be of use to the committee.

It is proposed to conduct an educational experiment in which groups that have had the benefit of physics films over well-defined areas of instruction, for a considerable period of time, are compared with groups that have received instruction under similar conditions, but without the use of films. It is proposed to conduct the experiment in several of the member institutions where a minimum of five-hundred students of approximately the same age, intelligence, and school achievement, may be divided into equal groups, control and experimental; these will be taught by the same instructor, whenever possible, so as to avoid errors due to differences in training, attitude and teaching ability.

In order to delimit areas of instruction concretely enough so that all students in both groups

will spend an equal amount of time on the same specific body of materials, detailed study guides will be prepared; these study guides will direct the attention of the student along well-defined lines of thought, either by asking questions or by pointing out some definite thing for his consideration. At the present time negotiations are under way with two different organizations which have suitable films. The possibilities lie in a comparison of the silent films, or sound films, with the conventional control groups, or in a comparison of the silent films with the sound films. It is hoped that this latter combination may be made available.

Individual reports may be expected from committee members who are specialists along various lines, such as Professor E. R. Lyon, who has done a vast amount of work on the systematized use of color distinction for blackboard drawings, and Professor R. L. Petry, who has made a thorough study of animated films in their relation to physics teaching.

F. J. SHOLLENBERGER, *Chairman*

THE COMMITTEE ON THE IDEAL UNDERGRADUATE CURRICULUM

THE committee on the ideal undergraduate curriculum is composed of the following members: Orrin H. Smith, DePauw University, *Chairman:* F. C. Blake, Ohio State University; J. B. Brinsmade, Williams College; H. W. Farwell, Columbia University; A. A. Knowlton, Reed College; G. E. Owens, Antioch College; O. M. Stewart, University of Missouri; L. W. Taylor, Oberlin College.

As a preliminary attempt to define our problems and objectives, the following list of questions and statements has been formulated. There is no pretension that the list is exhaustive; it merely represents the questions about which the committee is thinking at present.

(1) To what extent is the plan of majors and minors employed in liberal arts colleges? A survey of the number of hours required for majors and minors, based on a study of catalog requirements, might be of value.

(2) Should general physics be followed by special courses in heat, electricity, light, etc., or should it be followed by other courses in general physics, each cutting a little deeper than the preceding one?

(3) Can non-technical students be taught to advantage in the same classes with technical students? How many of our graduate students come out of non-technical courses? Is it advisable to provide descriptive courses for non-technical students? What should be the mathematical requirements for such courses? What attitude should be taken toward junior and senior courses that are purely descriptive or historical? Should physics major requirements ever be considered that do not involve the calculus?

(4) Should a major for an undergraduate student who expects to teach in a secondary school be essentially the same as for one who intends to enter a graduate school?

(5) If it is true that we need broad men sharpened to a point, how broad should be the training of these men? How much sharpening should be done in undergraduate work? What is the best list and the amounts, and distribution of supporting courses?

(6) What attitude should be taken toward science orientation courses? Should such courses be required or elective? Should they be provided for freshmen or for seniors?

(7) What common ground can we find in the published objectives of colleges and universities? Can this common ground, if found, be taken as of general significance in education or would it be like settling the law of gravitation by popular vote? What common ground can be found in the published objectives of departments of physics and is this ground common with that of the institutions? Is there any way to find out?

(8) What are the best evidences of success for a department of physics as judged by its graduating majors?

(9) To what extent are minors in physics concerned with it principally as a service course?

(10) Should a definite course in modern physics be offered to undergraduates? Should it be given with or without laboratory work? To what extent can we justify expense for equipment in such a course when funds are limited?

A warning is sounded against attempts to standardize excessively the work in physics departments, attempts to adopt a mass production technique which loses sight of the student as an individual, and the tendency to make of physics departments merely service departments for others and for professions and industry.

ORRIN H. SMITH, *Chairman*

The Committee on Preparation in Mathematics for College Physics

THE members of the committee on preparation in mathematics for college physics are: C. J. Lapp, University of Iowa, *Chairman:* A. A. Bless, University of Florida; Thomas D. Cope, University of Pennsylvania; C. H. Dwight, University of Cincinnati; A. T. Jones, Smith College; Carl W. Miller, Brown University; Carlton C. Murdock, Cornell University.

It has been assumed by most teachers that it is almost hopeless to attempt to teach college physics to a student without college mathematics as a prerequisite. Students have been quick to recognize this assumption on the part of the teacher and seek an easy refuge from their lack of achievement in physics by blaming their poor mathematical preparation.

Noteworthy accomplishment has been made in the last ten years in experiments in teaching[1] fundamental physics to students without mathematical preparation. It appears that there is a growing suspicion among a few college teachers that perhaps the importance of mathematical training to an understanding of fundamental physics has been overestimated.

In its approach to the problem the Committee proposes: first, to discover what reliable experimentation has been done on the subject; second, to determine what mathematics is actually used in college physics; third, to propose and encourage educational research aimed to throw light on the nature and solution of the problems involved in the mathematical preparation for college physics.

The work on this subject known to the Committee at the present time is as follows:

At the University of Pennsylvania, the students entering premedical physics are given mimeographed sheets of mathematical skills with instruction to master these techniques if they do not already have them.

C. H. Dwight, University of Cincinnati, has prepared a handbook entitled *Elements of Mathematics for General Physics.* The material in this unpublished manuscript was selected on the basis of his experience as a teacher.

D. A. Wells, University of Cincinnati, has published a useful eleven-page pamphlet on *The Construction of Graphs.*

A. A. Bless, University of Florida, reported a short study, *The Dependence of Physics on the Mathematical Preparation*, in Science **75**, 343 (1932).

A work book with diagnostic tests and remedial material, entitled *The Mathematical Prerequisites for First Year College Science*, has been prepared by Knight, Lapp and Rietz, of the University of Iowa. It will be published soon by Scott, Foresman and Company.

Six master's theses have been completed or are in progress at the University of Iowa in which the problems appearing in various textbooks are analyzed for the specific algebraic, geometric and higher mathematical skills found in their solutions. The authors of the theses and the textbooks examined are as follows:

Helen Q. Scribner (1929), *Physics*, by G. W. Stewart;
P. Sharar (1932), *College Physics*, by A. Wilmer Duff;
C. Baskerville (1930), *Physics for Colleges*, by Sheldon, Kent, Patton and Miller;
J. Bondhus (in progress), *Physics*, by Duff and Others, 7th edition;
M. Flanders (in progress), *A Survey of Physics for College Students*, by Frederick A. Saunders;
J. Beatty (in progress), *Physics for College Students*, by A. A. Knowlton.

Other theses completed at the University of Iowa include:

B. H. Graeber, *A Study of Mathematics Errors in a First Course in College Physics*, master's thesis (1932);
W. R. Lueck, *A Study of Arithmetical and Algebraic Disabilities of Students Pursuing College Physics*, Ph.D. thesis (1932).

This list of studies is necessarily incomplete. The Committee will appreciate information concerning studies pertaining to the subject.

C. J. Lapp, *Chairman*

[1] The courses referred to are "Acoustics," taught by G. W. Stewart, University of Iowa, and "Light and Color," taught by E. P. T. Tyndall, University of Iowa. Each course is three semester hours.

The Committee on Tests and Measurements

THE committee on tests and measurements is composed of the following members: C. J. Lapp, University of Iowa, *Chairman;* H. W. Farwell, Columbia University; Frederic Palmer, Jr., Haverford College.

In June, 1932, the President of the American Association of Physics Teachers requested the writer to organize systematic cooperation between the Association and the Cooperative Test Service of the American Council on Education. The preparation of the best possible college physics tests was part of the program of the Cooperative Test Service.

Before the beginning of the cooperative project, H. W. Farwell, of Columbia University, who has had broad experience in physics testing, had prepared two forms that were used in many colleges a year ago. The Test Service decided it wanted additional forms for standard college work and a cooperative plan with the A.A.P.T. was adopted.

Exacting college tests are so difficult to prepare that it is next to impossible for a single individual to do the work. Tests of the multiple-situation type were prepared for mechanics, heat and sound by members of the A.A.P.T. and administered in two forms to thirteen colleges and universities at the end of the first semester of 1932–33. The test papers have all been returned to the chairman and are now being studied. The tests were prepared by H. W. Farwell, H. Hoge, C. J. Lapp, Frederic Palmer, Jr., and Helen Q. Scribner.

A companion test over electricity, magnetism, modern physics and light is now being prepared and it is expected that it will be available for trial purposes at the end of the second semester.

C. J. Lapp, *Chairman*

Announcements and News

The local committee of arrangements for the next annual Christmas meeting, to be held in Boston, has been appointed as follows: Professor N. Henry Black, Harvard University, *Chairman;* Professor George R. Harrison, Massachusetts Institute of Technology; Professor Norton Kent, Boston University; Professor Louise S. McDowell, Wellesley College; Professor Carl A. Pearson, Simmons College.

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Professor F. Palmer, Jr., and Professor William S. Webb, who have represented the A.A.P.T. on the Council of the American Association for the Advancement of Science for the past two years, have resigned. In their places have been appointed Professor O. H. Blackwood, of the University of Pittsburgh, and Professor William E. McElfresh, of Williams College.

Among the articles and contributions that will appear in forthcoming issues of *The American Physics Teacher* are:

Problem of an International System of Physical Units and the Teaching of Such Units to American Students — ***Arthur E. Kennelly***

Heresy Concerning Specialized Physics Courses — ***G. W. Stewart***

Survey Course in Physics for Seniors in Engineering — ***Marsh W. White***

Undergraduate Research — ***Frederic Palmer, Jr.***

Facing Reality in the Teaching of Magnetism — ***D. L. Webster***

Improved Franklin's Flask and Simplified Cryophorus — ***Isay Balinkin***

Apparatus for the Electrolysis and Synthesis of Water and the Photosynthesis of HCl — ***J. G. Black***

Vapor Pressure Apparatus for Laboratory Use — ***A. H. Croup***

ABSTRACTS

Abstractors for This Number: Julian F. Evans, F. E. Knowles, Duane Roller, William Schriever, G. A. Van Lear, Jr.

Apparatus, Demonstrations and Laboratory Practice

38. A convenient and practical cork borer appliance. R. E. Dunbar; *Chemist-Analyst* **21**, 21, Nov., 1932. The edge of a cork borer soon becomes dull if the corks are placed against hard wood, metal or stone. To prevent this, place the corks against a board upon which has been glued a sheet of cork bulletin-board material. A removable tray placed below the board will serve to hold the cork borers and to catch waste material. D. R.

39. The kukulograph. M. J. Hoferer, *Sci. Amer.* **148**, 31, Jan., 1933. Describes an extremely simple and easily constructed device for producing curves which show the combination of two harmonic motions having any desired frequency ratio, amplitude and phase difference. W. S.

40. An adjustable stopcock remover. R. W. Westerman; *Ind. and Eng. Chem.* **25**, 68, Jan., 1933. The author states that this adjustable chuck has been used in removing plugs from a great many sizes and kinds of badly frozen stopcocks without breaking a single one. (Figs. 1 and 2.)

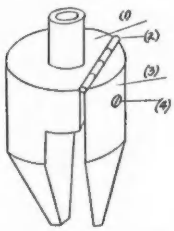

Fig. 1. Essential parts of the chuck described in Abstract 40: 1, main body which may be fastened to the stem of *C*-clamp; 2, hinge; 3, movable section held in position by the screw; 4, compression spring between the main body and the movable section.

"The two sections of the chuck are adjusted to fit the shoulder of the outside of the stopcock exactly, the handle of the plug remaining loose between the two sections of the chuck. In this position the chuck and stopcock are placed between the jaws of a vise or C-clamp so that a light steady pressure may be applied to the chuck and the shoulder of the stopcock on one side, and to the small end of the plug on the other side. A block of wood may be used at the end of the plug to prevent chipping. The rounded

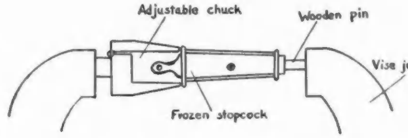

Fig. 2. Chuck used in a vise.

shoulder of the cock will be strong enough to withstand the pressure from the soft metal (brass) of the chuck. The light pressure thus applied will soon loosen the plug from the body of the cock. If necessary, the removal may be aided by warming the body of the stopcock with hot water or a match flame." (Figs. 1 and 2.) D. R.

41. How to make fireproof cement. W. Clyde Lammey; *Pop. Mech.* **59**, 157, Jan., 1933. Gives a formula for making a fire-proof cement which is suitable for insulating heating elements, etc. F. E. K.

42. A screening tube for electrometer leads. A. J. Davies; *J. Sci. Inst.* **10**, 22, Jan., 1933. A new design of screening tube for electrometer leads is described. The lead, a length of No. 28 s. w. g. bare copper wire, is soldered at both ends to short lengths of brass 4 b.a. threaded rod. These pass through two thimble-shaped pieces of amber, one at each end of the screening tube respectively. The thimbles at their bell-shaped ends rest against three 8 b.a. screws, inserted symmetrically around the brass screening tube. The amber thimbles press against these screws by reason of the tension of the lead produced by screwing down nuts on the ends of the brass rods which project through the thimbles. This arrangement has the advantage that the lead may be removed by unscrewing two nuts, one at each end of the tube. J. F. E.

43. Pyranol—a new liquid insulator. A. E. B.; *Sci. Amer.* **148**, 48, Jan., 1933. This new product of the General Electric Company has all the advantages of mineral oil for an insulating and cooling medium, and in addition is non-inflammable and non-explosive. The liquid, which is made in various forms, is chemically stable so that there is no sludging after continued exposure to heat and air. Viscosity and freezing point can be varied to suit conditions without affecting other properties. W. S.

44. A laboratory suggestion. M. J. McHenry; *Sch. Sci. and Math.* **33**, 322, Mar., 1933. To remove a frozen glass stopper from a reagent bottle, first invert the bottle for a day or two in water that has been strongly acidulated with hydrochloric acid and then dry the bottle, warm the neck and tap the neck gently. D. R.

45. Cellophane roll films for slide lanterns. Ross Bonar, Floyd Bonar and Earl C. H. Davies; *J. Chem. Ed.* **10**, 92–94. Feb., 1933. A cellophane roll film of standard width for slide lanterns may be quickly made from thin commercial wrapping cellophane by the use of carbon paper typing or by pen drawings. A roll of cellophane 0.001 in. thick and 400 in. long, wound on a 3/16-in. core, is less than ¾ in. in diameter. Such a roll is equivalent to 120 slides, with a capacity for at least 8000 words, yet weighs less than one glass slide. These rolls are inserted in and operated by an easily constructed roll carrier which fits into the opening occupied by the slide carrier of the ordinary lantern. Carbon paper impressions on cellophane smear easily. Such typing may be made more permanent by passing the typed film through a suitable liquid, such as ethyl acetate, followed by blotting and drying. (The authors.) See also *Science* **77**, 217–218, Feb. 24, 1933.
J. F. E.

46. A waterproof glass and metal cement. Anon; *Pop. Mech.* **59**, 335, Feb., 1933. Tells how to make and apply a hard, waterproof adhesive for uniting glass or metal parts. It will set under water and will resist fairly high temperatures. The ingredients are cement, litharge and glycerin.
F. E. K.

47. Solution for preventing rust. Anon; *Pop. Mech.* **59**, 331, Feb., 1933. Gives a method for removing rust from tools and for applying a protecting surface. F. E. K.

48. Protecting labels from moisture. Anon; *Pop. Mech.* **59**, 319, Feb., 1933. Tells how to attach labels to bottles and finish with a moisture-proof coating. Acids and strong alkalies remove these labels. F. E. K.

49. Inexpensive apparatus. Clarence C. Vernon; *J. Chem. Ed.* **10**, 188, Mar., 1933. If laboratory tongs are not available, a beaker containing a hot liquid can be handled by wrapping around the beaker a *doubled* length of fabric-lined pressure tubing and grasping the doubled and loose ends of the tubing with the hand. Fabric-lined pressure tubing may also be used in a similar fashion to obtain a secure grip on the screw caps of bottles and jars.
D. R.

50. Rapid photo-printer for small shops. H. C. Karloske; *Pop. Mech.* **59**, 477, Mar., 1933. Describes a photo-printer that can be made with ordinary tools and materials.
F. E. K.

51. Demonstrating atomic structure. Ralph E. Wellings; *J. Chem. Ed.* **10**, 179–180, Mar., 1933. A simple, effective apparatus has been designed for teaching atomic structure to high-school classes. It consists of a board painted with white circles to represent electron orbits and a number of pegs which represent the electrons. These electrons can be set into their proper places in the various orbits. The atomic nuclei are cut from cardboard and hung at the center of the rings. The atomic weights and numbers are drawn on these nuclei. Electron transfer, chemical changes, the periodic law, etc., can be more easily explained by the use of this model. J. F. E.

52. A model to illustrate the motion of a diatomic rotator with two degrees of freedom. Lewis Simons and E. H. Smart; *Proc. Phys. Soc.* **45**, Part 2, 266–270, Mar., 1933. An arm 5 in. long is pivoted at one end and carries at the other end a small electric lamp which is thus capable of moving on the surface of a sphere about the pivot as center. The two angular velocities $\dot{\phi}$ and $\dot{\theta}$ can be independently controlled by two-hand regulated motors: ϕ is the azimuthal and θ the co-latitudinal angular co-ordinate of the arm. If $\dot{\phi}$ and $\dot{\theta}$ are commensurable, the resulting figure traced out by the lamp remains stationary in space. This path represents the motion of one of the atoms of the rotator which has two degrees of freedom. (The authors.)
J. F. E.

53. A method for the determination of the specific heats of liquids, and a determination of the specific heats of aniline and benzene over the approximate range 20°C to 50°C. Allan Ferguson and J. T. Miller; *Proc. Phys. Soc.* **45**, Part 2, 194–207, Mar., 1933. Although intended for precision work, the method described is suitable for the intermediate student-laboratory. It can be used to determine specific heats, specific volumes and latent heats of organic liquids, and also to determine Joule's equivalent J in a way that has some advantages over the electrical methods described in the textbooks. The method for determining the specific heats of aniline and benzene consists in supplying by means of a heating coil the electrical power E^2/R necessary to hold a copper calorimeter and its contents steady at various temperatures θ above that of the surroundings. After the highest temperature, say 50°C, has been reached, the current is cut off and a cooling curve is taken in order to evaluate the constant K in the equation,

$$(MS+W)K\theta^{5/4}=E^2/RJ,$$

where M is the mass of the liquid, S is the specific heat of the liquid at the temperature θ above that of the surroundings and W is the water equivalent of the calorimeter. For each value of E^2/R one can then obtain the value of S at the corresponding temperature. With ordinary apparatus an accuracy of 1 percent or better is claimed.
D. R.

General Physics and Related Fields

54. The eclipse, bad weather, and a way out. Henry Norris Russell; *Sci. Amer.* **147**, 338–339, Dec., 1932. Describes briefly a new telescope designed by Lyot which gets rid of the light scattered by the edge of the objective lens, as well as much other scattered light, and shows how this instrument will enable a spectrographic study of the solar prominences to be made on any clear day without the necessity of a total eclipse of the sun. W. S.

55. How did Joule pronounce his name? Joseph O. Thompson; *Science* **77**, 88–89, Jan. 20, 1933. According to Professor P. G. Tait, who worked with him, Joule gave the *ou* in his name the sound of *ou* in *you*. J. F. E.

56. Injuries produced by contact with electric circuits. W. B. Kouwenhoven and O. R. Langworthy, *J. Frank. Inst.* **215**, 1–26, Jan., 1933. Reports the results of work done at the Johns Hopkins University on the effects of electric shock. Case histories of human beings were supplemented by experiments made with rats and dogs. It was found that low-voltage a.c. shocks are much more deadly than d.c. shocks of the same voltage. At voltages of 1000 and higher the reverse is true. In either case the injury increases with the voltage. High voltages produce such violent contraction of the muscles that the victim is often thrown clear, whereas at low voltages the muscular contraction is steady and it is difficult for the person to release his hold. The resistance of a body is made up of two parts—the contact resistance, and the ohmic resistance of the body proper. The resistances offered at the contacts are of the nature of a voltage drop and are largely independent of the current flowing. The contact resistance offered by the calloused hand of a laborer may equal 10^5 ohm·cm^{-2}. In water this resistance may fall to 1200 or 1500 ohms·cm^{-2}. Most accidents due to contact with low-voltage circuits occur in bathrooms and other places where moist conditions lower the contact resistance to a negligible value. The resistance of the body itself is relatively low, blood being a good conductor. In electrocutions where the contacts are good, the body resistance is of the order of 200 ohms. In humans an alternating current of 90 to 100 milliamp. is considered dangerous. The current density is also important. A small animal does not recover from a shock as readily as a large one and the authors suggest this as a possible reason for the belief that thin people are more susceptible to electric shock than large individuals. Death from electric shock may occur from a number of different causes, such as asphyxiation caused by the prolonged contraction of the muscles during the passage of the current, the failure of the ventricles of the heart to beat with a coordinated rhythm, the destruction of nerve cells of the respiratory center, and an increase above the safe limits of the body temperature by the Joule effect of the current flow. Burns and other complications may also cause death. In electrical accidents death is often only apparent. Immediate and sustained artificial respiration is important. Few individuals who have recovered from an electrical injury show any permanent disability. The paper discusses many other interesting results. An extensive bibliography is included. D. R.

57. Delicate instruments tame wild airplanes. Andrew R. Boone; *Sci. Amer.* **148**, 12–13, Jan., 1933. Describes very briefly some of the tests which are being made in the Guggenheim wind tunnel at the California Institute of Technology; eight reproductions of photographs illustrate the article. W. S.

58. The new wave-atom, elusive and mysterious. C. J. Phillips; *Sci. Amer.* **148**, 14–17, Jan., 1933. An interesting popular article, entirely non-mathematical, describing the wave-atom. It gives a very helpful picture for the student—at least as much of a picture as he can expect to get. W. S.

59. The amazing process of vision. Henry Norris Russell; *Sci. Amer.* **148**, 20–21, Jan., 1933. Compares the sensitivity of the human eye with that of the photographic plate. In the violet, for a line which the eye sees at a glance, the photographic plate requires an exposure of one minute; in the blue (λ4500) the visible line must be exposed 15 minutes; in the green (λ5200) the visible line requires an exposure of *30 hours;* for the red hydrogen line the exposure drops to 17 minutes; and in the extreme visible red the exposure time drops to one minute. The working range of the human eye is such that the faintest visible light is only $1/3\times10^{11}$ of that of full sunlight. The sensitivity of the eye increases with the time that the eye has been in total darkness. This increase of sensitivity is hardly appreciable until after a 10-minute interval of total darkness; during the next ten minutes in darkness the increase is great; during the third 10-minute interval the sensitivity increases more than eight times as much as during the second interval; during the next half hour the increase in sensitivity is little more than during the second 10-minute interval. In other words the full sensitivity of the eye is not attained until after it has been in total darkness for at least an hour. W. S.

60. Echoes give ocean depths. Herbert Grove Dorsey; *Sci. Mo.* **36**, 65–68, Jan., 1933. Ocean depths are determined by measuring the time of travel of a sound wave from the ship to the bottom and back, the apparatus being so designed that visual readings are obtained, even for depths as small as 6 fathoms. The apparatus described is used on hundreds of ships, and by the U. S. Coast and Geodetic Survey in its hydrographic surveys. The author (who is also the inventor of the device) is the principal electrical engineer of the U. S. C. and G. S. G. A. V.

61. A geographic study of cosmic rays. Arthur H. Compton; *Sci. Mo.* **36**, 75–87, Jan., 1933. After a brief review of the theories of Millikan, Jeans, and Dauvillier concerning the nature and origin of the cosmic rays, the

various ways in which previous attempts have been made to determine their nature are described, and the results summarized. It is made clear that "by far the most significant study that could be made of this question would be an extensive survey of the strength of the cosmic rays in different parts of the earth." The principal objectives of the survey which was accordingly undertaken (and which is still in progress) are outlined as: "(1) to obtain as extensive information as possible regarding the distribution of cosmic rays over the earth; (2) to study the variation in intensity of the cosmic rays with altitudes in different locations; and (3) to see whether there exists any difference between the cosmic-ray radiation in daytime and at night." The results thus far obtained, combined with the balloon observations of Piccard and of Reggener, are presented and interpreted. The sets of data respectively related to the three objectives, together with theoretical considerations which are outlined, lead to three corresponding conclusions: (1) The cosmic-ray intensity shows a decided minimum at the magnetic equator, but is sensibly constant at higher latitudes, lending strong support to the view that associated with the cosmic rays "are electrons (or at least electrified particles) which originate at an altitude of not less than 15 miles." (2) Intensity increases steadily with altitude, the logarithmic intensity, when plotted against barometric pressure, levelling off at about 20–30 km, but showing no such maximum at a lower altitude as was earlier reported by Millikan and Cameron. "This would seem to rule out the possibility that the cosmic rays can be photons entering the earth's atmosphere from remote distances. . . . [But] supposing that the cosmic rays consist of electrons originating more than a hundred miles above the earth's surface, and going from there in all directions, the general characteristics of the intensity altitude curve can be readily accounted for." (3) A variation in intensity between day and night of the type to be expected (on the electron hypothesis) as a result of the diurnal variation of the earth's magnetic field is indicated, but is hardly certain. G. A. V.

62. New M. I. T. spectroscopy laboratory. A. E. B.; *Sci. Amer.* **148**, 100, Feb., 1933. A 10-room building in which the temperature is controlled to within 0.1°F from 60°; a floor slab six feet thick designed to eliminate vibration; rooms so well heat insulated that, without added heat, their temperatures would not drop more than one degree during three weeks of cold winter weather; humidity controlled to range between 35 and 45 percent the year round—these are some of the unusual features. W. S.

63. International radio tuning at long range. ARTHUR E. KENNELLY; *Sci. Mo.* **36**, 144–146, Feb., 1933. A brief account is given of a frequency intercomparison test conducted by the British National Physical Laboratory, as reported by the Committee on Standards of The International Union of Scientific Radio. A modulation frequency of 1000.00 cycles per second was broadcast and compared with local standards in seven countries. "The frequencies measured at these foreign stations, in terms of their own standards, as subsequently reported by them, varied between the limits of 1000.0002 and 999.997 cycles per second, a total range of 0.0005, or one part in two millions." The constant-frequency property of travelling radio waves which was thus checked is generally accepted, but, possibly, had not previously been submitted to so severe a test. G. A. V.

64. Light-weight transformers for aircraft. D. W. GRANT; *Bell. Lab. Rec.* **11**, 173–177, Feb., 1933. The development of radio communication for aircraft has created a demand for electrical equipment of light weight. The problem has been particularly difficult in the case of transformers. Permalloy may be used as the core for the purpose of increasing flux density, but for intense actuating fields the advantages of permalloy vanish. Other ways of attacking the problem are, special design of the winding space and use of air-gaps. By using carefully designed transformers, it has been possible to construct a complete radio receiving set weighing 17 pounds. J. F. E.

65. Electron tubes in Radio City theatres. ANON; *Electronics* **6**, 32–34, Feb., 1933. **The Radio City theatres—a pageant of modern lighting.** CLYDE R. PLACE; *Light* **2**, 6–9, 1933. Lighting effects and lighting-control, sound and air-conditioning applications of tubes in these ultra-modern theatres. D. R.

66. Radium-water generators. HERMAN SCHLUNDT, RALPH G. FULTON AND FRANK BRUNER; *J. Chem. Ed.* **10**, 185–187, Mar., 1933. Three appliances for rendering ordinary drinking water radioactive were tested. The quantities of radium emanation and radium present in water samples were determined when the appliances were operated according to directions of the manufacturer. "It is concluded that steady drinkers of water from even the most active type of generators do not stand in danger of contracting radium poisoning. The alleged therapeutic value of slightly radioactive waters probably rests more on the larger daily doses of water drunk than on the radon contained therein." D. R.

67. A geographic study of cosmic rays. ARTHUR H. COMPTON; *Phys. Rev.* **43**, 387–403, March 15, 1933. The results of the paper described in Abstract 61 are reported, with less discussion of the historical background and more detail regarding the apparatus used, observational technique, etc. The most significant addition is a comparison of the results with the theory of Lemaitre and Vallarta, which considers the effect of the earth's magnetic field on the motion of electrons approaching the earth from remote space. Agreement between the observed latitude variation and the predictions of this theory leads to the conclusion that, "the experimental data . . . give very strong support to Lemaitre and Vallarta's theory of the variation of cosmic-ray intensity with latitude. This means that this variation seems to be due to the presence in the cosmic rays of charged particles coming into the earth's atmosphere from remote space with an energy, if they are electrons, of about 7×10^9 electron-volts." G. A. V.

68. The atoms as a source of light. SAUL DUSHMAN; *Elect. Eng.* **52**, 173–175, Mar., 1933. A summary of present knowledge regarding the problem of producing "cold light." D. R.

69. The National Bureau of Standards. GEORGE K. BURGESS; *Sci. Mo.* **36**, 201–212, March, 1933. This article, the last written by the late director of the Bureau, is an introduction to a series of articles on that institution; the series itself is part of a more extensive one devoted to the scientific work of The Government of the United States, beginning in the January, 1933, issue. A comprehensive survey is given of the history, objectives, functions, equipment, and publications of this great research laboratory of pure and applied physics. G. A. V.

70. The problem of cosmic rays. WATSON DAVIS; *Educ. Focus* (*Bausch and Lomb*) **4**, 10–15, Apr., 1933. A non-technical summary by the editor of *Science Service*. D. R.

71. Teaching atomic weights. ERNEST A. WILDMAN, *J. Chem. Ed.* **10**, 238–240, Apr., 1933. This paper outlines Aston's mass-spectrographic procedure for determining the atomic weights of complex elements and suggests its suitability for presentation in the early part of the general chemistry course. D. R.

INTERMEDIATE AND ADVANCED PHYSICS

72. The new conception of matter in motion. THOMAS H. JOHNSON; *Sci. Mo.* **35**, 220–227, Sept., 1932. After an introductory exposition of the atomic theory of matter and the many facts which demand it, the question of what laws are to be used to describe the motion of matter and light are discussed. Newton's laws are rendered untenable for light and matter alike by the existence of diffraction and interference phenomena for both kinds of beams; the similarity of behavior is strikingly exhibited by reproducing plates showing crossed-grating patterns made with light and a crystal-reflection pattern made with an atomic beam. Both phenomena are explained on the wave-mechanical idea that the behavior of the corpuscles must be predicted by considering the propagation of an imaginary wave disturbance, the intensity of the wave giving the probability of the arrival of a corpuscle at the point in question. ". . . it is now possible to include all motion under one law; the same for light corpuscles, electrons, or large-sized objects." The reason why Newton's laws are applicable to large sized objects, as a very good approximation, is explained. G. A. V.

Comments by the abstractor: The conclusion of this article brings to mind a contradictory remark of Planck's: "Now if the quantum theory were superior or equal to the classical theory at all points, it would be not only feasible but necessary to abandon the latter in favor of the former. This, however, is definitely not the case. For there are parts of physics, among them the wide region of the phenomena of interference of light, where the classical theory has proved its validity in every detail, even when subjected to the most delicate measurements; while the quantum theory, at least in its present form, is in these respects completely useless. It is not the case that the quantum theory cannot be applied, but that, when applied, the results reached do not agree with experience." Max Planck, *The Universe in the Light of Modern Physics*, Norton, New York (1931), p. 101; this question is also discussed briefly, but more explicitly, in G. P. Thomson, *The Wave Mechanics of Free Electrons*, McGraw-Hill, New York (1930), p. 34.

73. A new analogy between mechanical and electrical systems. F. A. FIRESTONE; *J. Acous. Soc. Am.* **4**, 249–267, Jan., 1933. By considering each mass in a linear mechanical system as having two terminals, one fixed in the mass and one fixed to the frame of reference, every linear mechanical system is reduced to a multiplicity of closed mechanical circuits to which force and velocity relations similar to Kirchhoff's laws, may be applied. The conventional mechanical-electrical analogy is derived from the similarity of the equations $v=f/z$ and $I=E/Z$. It is incomplete in the following respects which lead to difficulty in its application. (I) There is a lack of analogy in the use of the words "through" and "across" which indicates a fundamental difference in the nature of the analogous quantities, for instance, force through and e.m.f. across. (II) Mechanical elements in series must be represented by electrical elements in parallel, and *vice versa*. (III) Mechanical impedances in series must be combined as the reciprocal of the sum of the reciprocals while electrical impedances in series are additive. (IV) There is an incompleteness in the mechanical analogues of Kirchhoff's laws. The new analogy is derived from the similarity of the following equations: $v=f\bar{z}$ and $E=IZ$ where $\bar{z}$ is the reciprocal of the mechanical impedance as usually defined. This new analogy is complete in all of the above-mentioned respects in which the old analogy failed. It leads to analogous relations of a simple sort and permits an equivalent electrical circuit to be drawn in an easy intuitive manner. (The author.) W. S.

74. The magneto-optic method of analysis. FRED ALLISON; *J. Chem. Ed.* **10**, 71–78, Feb., 1933. A summary of the work of the author and his collaborators on the magneto-optical method of analysis. Particular reference is made to the detection of elements 85, 87, and the heavy isotope of hydrogen. G. A. V.

75. Notes on the method of least squares. A. S. EDDINGTON; *Proc. Phys. Soc.* **45**, Part 2, 271–287, Mar., 1933. This paper is of importance to experimental physicists and to others who are interested in the theory of errors. Its purpose is "to controvert two rather prevalent ideas: (1) that the method of least squares is only justified if the errors of observation have a Gaussian distribution, and (2) that the orthodox theory of errors does not sanction any of the other methods of combining observations that are often used in practice." D. R.

HISTORY AND BIOGRAPHY

76. Sidelights on the era of Young and Fresnel. E. L. NICHOLS; *J. O. S. A.* **23**, 1–6, Jan., 1933. Incidents connected with the development of optical interference theory during the early part of the 19th century are related. Emphasis is placed upon the credit given by Young to Newton for contributions to the wave theory. Young's modest and undogmatic character is revealed by a quotation from one of his letters, written in 1815: "With respect to my own fundamental hypotheses respecting the nature of light I become less and less fond of dwelling on them, as I learn more and more facts like those which Mr. Malus discovered." (Malus discovered the phenomenon of polarization in 1810.) The collaboration between Arago and Fresnel in developing the undulatory theory of light is described. Arago, it is related, was, over the opposition of Laplace, elected at the age of 23 to the French Academy, principally because he had just returned from a series of thrilling adventures, including capture by the Barbary pirates! A year later Arago took up the study of polarization, immediately after its discovery by Malus. In 1815 he collaborated with Fresnel in experimental work to check the wave theory of light. One of Arago's most valuable contributions was to obtain permission from the government for Fresnel to return to Paris for a few months from a sort of forced exile in his home town. Later Arago could not stomach Fresnel's theory of transverse vibrations and the collaborators separated. Fresnel died from tuberculosis in 1827. His theory of transverse vibrations was not generally accepted until about 1850. J. F. E.

77. The genesis of flight instruments. M. F. BATES; *Sperryscope* **6**, 7–9, Jan., 1933. A brief nontechnical account of some of the flight instruments employed in the early days of aviation. Illustrated with 8 photographs. D. R.

78. Sadi Nicholas Léonhard Carnot. E. H. JOHNSON; *Sci. Mo.* **36**, 131–137, Feb., 1933. A sketch of the life and work of Carnot is given, together with a discussion of his views on heat and heat engines. Several quotations from his famous paper are given, and these are thrown into relief by explanations of the situations regarding theories of heat, etc., before and since its publication. G. A. V.

79. The discovery of the elements. MARY ELVIRA WEEKS; *J. Chem. Ed.* **10**, Feb.–Apr., 1933. A continuation of the series of articles described in Abstract 25, *A. P. T.* (1933). The titles of the present articles, with page numbers, are: The radioactive elements, 79–90; Recently discovered elements, 161–170; Cronology, 223–227. Provided a sufficient number of subscriptions is received, a collected edition of this series of articles by Miss Weeks will be prepared. The estimated price is **$1.50** for paper binding and **$2.00** for cloth binding. Subscriptions should be addressed to 20th and Northampton Streets, Easton, Pa. D. R.

80. David Rittenhouse—Physicist. THOMAS D. COPE; *J. Frank. Inst.* **215**, 287–297, Mar., 1933. The versatile and distinguished American, David Rittenhouse (1732–1796), was a keen student of physical problems. By trade a maker of high-grade clocks, Rittenhouse was on the frontiers of knowledge in several branches of physics and apparently anticipated a number of important discoveries that have since been worked out by others. D. R.

81. The derivations of the names of the elements. SAUL S. HAUBEN; *J. Chem. Ed.* **10**, 227–234, Apr., 1933. Brief discussions of the histories of the names of the elements. J. F. E.

82. The evolution of weights. ANON; *Laboratory* (*Fisher Sci. Co.*), **5**, 54–57, 1932. This brief article is illustrated with five photographs of historic weights, including one of the oldest known weight, a stone weight which dates from about 2960 B. C. and which is now in the Ashmolean Museum at Oxford. Until 1875, when the International Bureau of Weights and Measures was established, there were no international standards of weight. D. R.

83. The evolution of the thermometer. ANON; *Laboratory* **5**, 18–21, 1932. Good illustrations. D. R.

Physics Teaching and Science Education

84. A plan for developing a better technique in giving science demonstrations. Edith M. Selbert; *Sci. Ed.* **16**, 417–420, Oct., 1932. An analysis of the errors made by student teachers in class demonstrations for high-school science. D. R.

85. Invention—a coming profession. H. Olken; *Sci. Amer.* 148, 28–30, Jan., 1933. The author describes what he considers "invention" to be and attempts to show that modern education, that of engineering in particular, stifles the development of "inherent inventive faculties." He proposes that "training in the art of invention" should be a part of the engineering curriculum and, on the basis of his experience, suggests that it be under the supervision of the graduate department of the engineering school. W. S.

86. Physics as a basis of engineering. E. W. Davis; *Sch. Sci. and Math.* **33**, 204–206, Feb., 1933. The author, who is an electrical engineer with the Simplex Wire and Cable Company, sees in physics "the one fundamental science that is basic in practically all branches of human thought and human endeavor." "Too much attention is now being paid to educating specifically electrical engineers, mechanical engineers, civil engineers, etc. 'Forget the type of engineering and major in physics,' is my advice to students today." "There is no study in the entire school curriculum that can produce as much mental development as the study of physics and mathematics." D. R.

87. An experiment in visual education. J. O. Frank; *J. Chem. Ed.* **10**, 90–91, Feb., 1933. "The existing literature dealing with studies of the use of lantern slides in elementary chemical instruction reports a variety of results and conclusions. It is suggested that variables which have not received sufficient attention are: (1) the nature of the slides presented and (2) the method of presentation." "In the light of criticism from about forty students the following tentative conclusions were reached: (1) Students greatly prefer to see a set of slides and to hear a complete lecture at the beginning of a unit rather than later. (2) A whole set of slides covering a given unit is better received and given more attention by students than a few slides shown at intervals or covering only a few items. . . . (3) Slides used in teaching chemistry vary enormously in their teaching value. . . . (4) One of the greatest values resulting from the use of slides lies in the interest they induce. Some slides which seemed to have little teaching value were rated highly by students because they made the subject matter of the unit more interesting. (5) When either charts or tables can be used to teach a given item, the students prefer the charts. When diagrams or tables can be used, they prefer the diagrams. Yet when the essential figures in a table can be made conspicuous in some way or other, the students claim that they do learn easily from the tables. . . . (6) Students believe they learn more from slides carrying printed captions and printed notations labeling the various important features of the apparatus, device, or process shown by means of slides. Lettered parts are difficult to read and understand unless much time is given. (7) Students have considerable difficulty in reading script on a slide, no matter how clearly it may be written. Hand-lettering is more legible than script, and typewritten material more legible than hand-lettering. Boldface print seems to be more legible than any other form of lettering. (8) One great value of slides lies in the fact that time enough can be given an item so that its details can be mastered. Students were unanimous in quoting this as one of the important advantages of slides. (9) It is evident that slides are not equal to charts for showing apparatus of intricate design, or other material which has to remain in view for a considerable time." D. R.

88. Comparison of verbal accompaniments to films. William Francis Einbecker; *Sch. Rev.* **41**, 185–192, Mar., 1933. Some of the results of this carefully-conducted study made with 44 high-school physics students and 96 general science students are: films accompanied by oral comments are better comprehended than films without caption or comment, but it is immaterial whether it is the teacher or the speaker in the talking film who comments; silent films accompanied by the teacher's comments are superior both to the films alone or to speaking films for teaching new technical words or unfamiliar names. D. R.

89. Preparation of visual tests. Clyde Stewart; *Sch. Sci. and Math.* **33**, 323–325, Mar., 1933. To increase the effectiveness of screen visual material and to prevent the students from regarding it as mere entertainment, tests should be given on this material as well as on the regular class work. One method of testing is to project the material on the screen and have the students answer questions about it orally or on paper in the semi-darkened room. Another method is to have a mimeographed test of the objective type for each film or set of slides. The author gives a sample of such a test and suggests methods for transferring diagrams to the mimeograph stencil. D. R.

90. Science for the consumer. W. A. Partridge and Henry Harap; *Sch. Sci. and Math.* **33**, 266–274, Mar., 1933. In order to determine what scientific terms occur in publications intended for consumers, the terms used in the publications of Consumers' Research were recorded and classified. The names of the terms and of the commodities with which they occur are given in the paper. The total number of different terms found was 349 and these were used in connection with 718 commodities. The number of terms belonging to each school-science subject and (in parentheses) the number of commodities with which they occur were as follows: physics, 95 (177); chemistry, 85 (203); health and hygiene, 70 (118); biology, 52 (78); home economics, 44 (88); unclassified, 5. There are more terms listed under physics than under chemistry, but the chemistry terms are used more frequently and widely. Among the widely used physical terms are: automatic

switch, B. T. U., convection current, gravity, humidity, insulation, thermostat, viscosity, watt. D. R.

91. Professionalization of subject-matter courses in the education of science teachers. A. W. HURD; *Ed. Adm. and Sup.* **19**, 173–180, Mar., 1933. Present subject-matter courses planned primarily for future specialists are not the ones best fitted for prospective teachers of pupils who do not expect to become subject-matter specialists. Nor are courses in educational methods ideal, for they lack the concreteness necessary to make them tangible and practicable. A solution for these objections is offered by the professionalized subject-matter course, for it considers subject-matter always in its relation to the teaching of pupils and ties up discussion of teaching methods with concrete subject-matter. From 84 replies to a questionnaire sent to faculty members identified with the training of science teachers in various institutions and by visits to 31 teacher-training courses which claim to be professionalized, the author has obtained a number of criteria for judging such courses. D. R.

92. Research studies related to the teaching of science. CHARLES J. PIEPER; *Sci. Ed.* **16**, 297–302, Apr., 1932. Lists investigations concerning laboratory equipment and supplies, science tests, preparation of science teachers, supervision and administration of science instruction, and science teaching in foreign schools. D. R.

MISCELLANEOUS

93. Technical exposition for the general reader. JOHN MILLS; *J. Eng. Ed.* **23**, 354–364, Jan., 1933. An able discussion of the art of presenting scientific material to the general reader. D. R.

94. The art of technical writing. GEORGE A. STETSON; *J. Eng. Ed.* **23**, 491–498, Feb., 1933. The author, who is Editor of the American Association of Mechanical Engineers, summarizes his formula for writing a technical paper as follows: "(1) Become thoroughly familiar with the subject and assemble all the material at your disposal. Don't neglect the literature. (2) Decide upon the purpose and scope of the paper as affected by the occasion and the audience. Visualize the persons to be addressed, their familiarity with the subject matter, their education, interests, prejudices, etc. Determine the limitations of time, space, illustrative material, etc., and get from those who ask you to prepare the paper or who intend to publish it any special instructions that may be helpful to you. (3) List the major items to be covered and choose the material to be used. (4) Get a good title, not too long, not too general, but precise and significant. (5) Let the reader know at once what you propose to write about and of any major conclusions that can be effectively divulged. (6) Get his interest at the start and keep it. (7) Have him constantly in mind while you write and don't 'write down' to him. (8) Choose some logical order of presentation and stick to it, building on the reader's knowledge and interest. (9) Be careful in the choice of words and in the use of examples and analogies. Avoid pedantry and unusual terminology; explain unfamiliar words if they must be used. Use standard symbols and abbreviations. (10) Be brief, but clear and coherent. Save the reader's time and publication expense. (11) Leave out irrelevant details and qualifying phrases that are obviously unessential. Let curves, sketches, illustrations, and tables tell as many of the tiresome details as possible. Don't interrupt a well-planned story with substantiating material and mathematical demonstrations that can be relegated to appendices for the use of those particularly interested in them. Don't quote at length when you can refer to the original. (12) Give the reader a good bibliography but don't annoy him with too many footnotes. Provide a good summary and a brief synopsis. (13) When the paper is written, check it over to see if it is properly proportioned. Pay particular attention to first and concluding paragraphs. Check all references, figures, computations, mathematics, numerals, drawings, and other details. (14) Lay the paper aside and read it over several days later to make sure it is complete, well-proportioned, logical, and coherent. (15) Be properly humble about your paternity. Welcome rather than resent suggestions for improving your paper and give the editor as much credit for knowing his job as you would like to have him give you for knowing yours." D. R.

95. University patents. ALAN GREGG; *Science* **77**, 257–259, Mar. 10, 1933. The universities are in increasing numbers adopting the policy of patenting the results of research in order to obtain revenue for additional research. More attention has been given to the arguments in favor of such a policy than to those against it. Among the latter are: it discourages unselfish exchange of ideas, discourages a critical and impartial attitude, tends to provoke bitterness and to consume time and money in litigation, provides an excuse for the public to leave research in the universities to earn its own way, and may possibly influence the choice of university personnel and the choice of research problems. The author cites several actual cases in support of his arguments. D. R.

96. What the machine is doing to mankind. JAMES SHELBY THOMAS; *J. Frank. Inst.* **215**, 247–272, Mar., 1933. In this defense of the machine and industrialism, the author, who is economist for Commonwealth and Southern Corporation of New York, answers those critics who believe that there is no beauty in the machine, that it destroys artistry in the product and that it throws men out of work. D. R.

97. Evolution of society as influenced by the engineer. JOHN C. MERRIAM; *Elect. Eng.* **52**, 171–173, Mar., 1933. The president of the Carnegie Institution outlines the influences of the engineer on society and indicates methods whereby the engineer might be of still greater use in the development of a well-informed and intelligent society.

D. R.

GENERAL EDUCATION

98. Who are the good teachers? L. P. SIEG; *Sch. and Soc.* **36**, 481–485, Oct. 15, 1932. The author discusses, among other things, several qualities which he believes every teacher should possess. These are: a knowledge not only of his own subject, but of related subjects as well; ability to inspire students; a kindly and considerate manner; loyalty to his institution; the ability to make his subject interesting; a good listener; an orderly manner; ability to discipline if necessary; capacity to realize his shortcomings. D. R.

99. The present state of ignorance about factors effecting teacher success. STEPHEN M. COREY; *Ed. Adm. and Sup.* **18**, 481–490, Oct., 1932. A review of the studies which have been made of such factors as age, teaching experience, grades in academic subjects, etc., lead to the conclusion that "it should be at present impossible for any conscientious individual to advise students whether or not they should continue training for teaching. Despite our prejudices and deeply rooted convictions, the critical thinker will realize that, beyond some obvious physical handicaps such as blindness, deafness, or an extreme speech defect, we have no sound evidence to justify our recommendations."

D. R.

100. U. S. Office of Education serial publications. E. M. WITMER AND M. C. MILLER; *Teachers' Coll. Rec.* **34**, 302–311, Jan., 1933. An annotated check list of the publications of the U. S. Office of Education. D. R.

101. What becomes of the college graduate? ANTHONY ANABLE; *Chem. and Met. Eng.* **40**, 83–85, Feb., 1933. A study has been made of the careers of 1000 graduates of the course in business and engineering administration at Massachusetts Institute of Technology. The collecting of data was begun in 1917 by Professor Davis R. Dewey and the records have been correlated by Dewey's successor, Professor Erwin H. Shell. From the results it appears that in order to be among the upper 20 percent of successful administrators in modern industry one should have the following characteristics. "(1) A good standing in classroom work, well above the average in all subjects, but especially high in thesis work, and in business and economic subjects where latent initiative, imagination, and resourcefulness are developed. (2) Proficiency in extra-curriculum activities, particularly those calling for managerial and organizing abilities and the subtle technique of leading others and making the others like to be led. (3) Ability to get along well with others—a natural and deserved popularity if you will—indicated by election to membership in honorary and social fraternities. (4) Success in securing employment in a growing and remunerative industry, such as the chemical and related processing industries, a gradual working into the more lucrative fields of that industry, such as distribution, finance, and management, and finally the attainment of an executive position in the active direction of that industry rather than a less remunerative functional or staff position." D. R.

102. Educational tests and their uses. BEN. D. WOOD, W. J. OSBURN, G. M. RUCH, M. R. TRABUE, GRACE A. KRAMER, JOHN L. STENQUIST, E. F. LINDQUIST, H. R. ANDERSON; *Rev. Ed. Research* **3**, 1–80, Feb., 1933. This comprehensive review of the subject of educational tests was prepared by the American Educational Research Association's committee on educational tests and their uses. It is presented in five chapters: basic considerations, selection of test items, recent developments in statistical procedures, recent developments in testing for guidance, recent developments in the uses of tests. The accompanying bibliography contains 467 references. D. R.

103. Training of graduate students for college teaching. FERNANDUS PAYNE; *A.A.U.P. Bull.* **19**, 127–144, Feb., 1933. This report of a committee of the Association of American Universities suggests many things which the graduate schools, the colleges, the teachers, and the students may do to foster better teaching and learning.

D. R.